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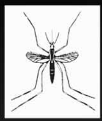
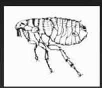
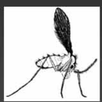
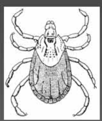
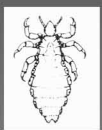

Regional Disease Vector Ecology Profile

East Asia

Defense Pest Management Information Analysis Center
Armed Forces Pest Management Board
Forest Glen Section
Walter Reed Army Medical Center
Washington, DC 20307-5001

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PREFACE

Disease Vector Ecology Profiles (DVEPs) summarize unclassified literature on medically important arthropods, vertebrates and plants that may adversely affect troops in specific countries or regions around the world. Primary emphasis is on the epidemiology of arthropod-borne diseases and the bionomics and control of disease vectors. DVEPs have proved to be of significant value to commanders, medical planners, preventive medicine personnel, and particularly medical entomologists. These people use the information condensed in DVEPs to plan and implement prevention and control measures to protect deployed forces from disease, injury, and annoyance caused by vector and pest arthropods. Because the DVEP target audience is also responsible for protecting troops from venomous animals and poisonous plants, as well as zoonotic diseases for which arthropod vectors are unknown, limited material is provided on poisonous snakes, noxious plants, and rodent-borne diseases such as hantavirus and leptospirosis.

In this document vector-borne diseases are presented in two groups: those with immediate impact on military operations (incubation period < 15 days) and those with delayed impact on military operations (incubation period > 15 days). For each disease, information is presented on military importance, transmission cycle, vector profiles, and vector surveillance and suppression.

Additional information on venomous vertebrates and noxious plants is available in the Armed Forces Medical Intelligence Center's (AFMIC) Medical, Environmental, Disease Intelligence, and Countermeasures (MEDIC) CD-ROM.

Contingency Operations Assistance: The Armed Forces Pest Management Board (AFPMB) is staffed with a Contingency Liaison Officer (CLO), who can help identify appropriate DoD personnel, equipment, and supplies necessary for vector surveillance and control during contingencies. Contact the CLO at Tel: (301) 295-8312, DSN: 295-8312, or Fax: (301) 295-7473.

Defense Pest Management Information Analysis Center (DPMIAC) Services: In addition to providing DVEPs, DPMIAC publishes Technical Information Bulletins (TIBs), Technical Information Memorandums (TIMs), and the Military Pest Management Handbook (MPMH). DPMIAC can provide online literature searches of databases on pest management, medical entomology, pest identification, pesticide toxicology, venomous snakes, poisonous plants and other biomedical topics. Contact DPMIAC at Tel: (301) 295-7476, DSN: 295-7476, or Fax: (301) 295-7473. Additional hard copies or diskettes of this publication are also available.

Other Sources of Information: The epidemiologies of arthropod-borne diseases are constantly changing, especially in developing countries undergoing rapid growth, ecological change, and/or large migrations of refugee populations resulting from civil strife. In addition, diseases are underreported in developing countries with poor public health infrastructures. Therefore, DVEPs should be supplemented with the most current information on public health and geographic medicine. Users may obtain current disease risk assessments, additional information on parasitic and infectious diseases, and other aspects of medical intelligence from the Armed

Forces Medical Intelligence Center (AFMIC), Fort Detrick, Frederick, MD 21701, Tel: (301) 619-7574, DSN: 343-7574.

Vector Risk Assessment Profiles (VECTRAPs) for most countries in the world can be obtained from the Navy Preventive Medicine Information System (NAPMIS) by contacting the Navy Environmental Health Center (NEHC) at Tel: (757) 762-5500, after hours at (757) 621-1967, DSN: 253-5500, or Fax: (757) 444-3672. Information is also available from the Defense Environmental Network and Information Exchange (DENIX). The homepage address is: <http://denix.army.mil/denix/denix.html>.

Specimen Identification Services: Specimen identification services and taxonomic keys can be obtained from the Walter Reed Biosystematics Unit (WRBU), Museum Support Center, MRC-534, Smithsonian Institution, Washington, DC 20560 USA; Tel: (301) 238-3165; Fax: (301) 238-3667; e-mail: <wrbu@wrbu.si.edu>; homepage: <http://wrbu.si.edu/>.

Emergency Procurement of Insect Repellents, Pesticides and Equipment: Deploying forces often need pesticides and equipment on short notice. The Defense Logistics Agency (DLA) has established the following Emergency Supply Operations Centers (ESOCs) to provide equipment and supplies to deploying forces:

> **For insect repellents, pesticides and pesticide application equipment:** Contact the Defense Supply Center Richmond ESOC at Tel: (804) 279-4865, DSN: 695-4865. The ESOC is staffed seven days a week/24 hours a day. Product Manager (804) 279-3995, DSN: 695-3995.
>
> **For personal protection equipment (bednets, headnets, etc.) and respirators:** Contact the Defense Supply Center Philadelphia ESOC Customer Assistance Branch at Tel: (215) 737-3041/3042/3043, DSN: 444-3041/3042/3043.

Every effort is made to ensure the accuracy of the information contained in DVEPs. Individuals having additional information, corrections, or suggestions, are encouraged to provide them to the Chief, DPMIAC, Armed Forces Pest Management Board, Forest Glen Section, Walter Reed Army Medical Center, Washington, DC 20307-5001, Tel: (301) 295-7476, DSN: 295-7476, or Fax: (301) 295-7473.

Acknowledgments: The initial draft of this DVEP was prepared by Dr. John B. Gingrich, LTC USA (retired), Dr. Harold J. Harlan, LTC USA (retired), Dr. Peter V. Perkins, COL USA (retired) and Dr. James H. Trosper, CDR USN (retired). Subsequent technical reviews and recommendations were provided by DPMIAC's LTC Richard N. Johnson, USA, Dr. Richard G. Robbins, CDR George W. Schultz, USN, LTC Raymond Dunton, USA, and 1st Lt Jessica Finkelstein, USAF. Additional reviews were provided by COL Phillip G. Lawyer, USA, and Dr. Timothy H. Dickens, CDR USN (retired), as well as by the personnel of the Armed Forces Medical Intelligence Center. The cover design is the work of Mr. J. Rees Stevenson of DPMIAC. Experts were consulted for the taxonomic accuracy of respective arthropod groups discussed in the DVEP. Dr. James E. Keirans, Georgia Southern University, reviewed the ticks.

Dr. Robert E. Lewis, Iowa State University, reviewed the fleas. COL Phillip G. Lawyer (USUHS) and Dr. Peter V. Perkins reviewed the sand flies. Dr. Roy McDiarmid, National Museum of Natural History, reviewed the snakes. MAJ Scott A. Stockwell, U.S. AMEDD Center and School, reviewed the scorpions, and Mr. James Pecor of the US Army Walter Reed Biosystematics Unit reviewed the mosquitoes.

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EXECUTIVE SUMMARY

East Asia Profile.

Geography. East Asia encompasses almost 11.5 million sq km of land. Its topography varies from some of the world's highest mountains in the south and west to high plains in the north and northwest, and from broad bands of steppes and hills stretching from the northeast to the central and south-central areas, to the broad river valleys and plains along the eastern and southeastern coasts. East Asia also includes the fairly rugged mountain chains that run northeast to southwest nearly through the centers of the main islands of Japan and Taiwan. The vast and high Tibetan Plateau, and several associated mountain ranges, have an average elevation of about 5,000 m. The highest peak in the world is Mount Everest, at 8,850 m, in the Himalayan Mountains near the center of Tibet's southern border with Nepal. The lowest point in the whole region is a depression at Turpan Pendi, at -154 m, in the north-central part of China's westernmost Xinjiang Province. Many of the mountains and even the hill areas are quite rugged throughout the whole region, making transportation and travel difficult. Desolate areas include most of Mongolia and the Tibetan Plateau, the far western provinces of China, the great steppes of eastern Mongolia and far northeastern China, and the high, dry, cold Gobi Desert in southern Mongolia and northeastern China. Most of this region has been under Communist governance for several decades, and Communist regimes still rule China and North Korea. Most of the countries in East Asia have an economy that is currently based on, or is progressing toward, a capitalist system. Hong Kong and Macau have recently reverted to the status of Special Administrative Regions (SARs) of China, and are currently operating under special "one country, two systems" agreements for predetermined transition periods of up to 50 years. Taiwan and China are progressing toward eventual reunification into a single nation, and recent political overtures and meetings between leaders of North Korea and South Korea have greatly raised hopes for reunification of these two states. All East Asian countries have very old civilizations with well-established cultural, religious (mainly Buddhist, Taoist, or Confucianist), ethnic (mainly Chinese, Japanese, or Korean), and family or tribal customs, ceremonies, beliefs, and practices. All of the larger countries in this region have significant natural resources but, in most cases, these have not yet been very well developed. Labor is relatively cheap throughout the region, and several of these countries depend on production and export of labor-intensive or light industrial products, such as electronics, textiles, fireworks, footwear, processed food and toys. Many of these countries, including North Korea, Mongolia, Macau, Hong Kong, and Taiwan, must import most of their power, fuel, food, water, industrial raw materials, and machinery. Great numbers of people live in areas where they are exposed to high altitude effects, bitter cold, wide daily and seasonal temperature fluctuations, severe storms (often associated with monsoons or typhoons), earthquakes, and flooding. Limited availability of fresh water, contamination of water with sewage and industrial wastes, air pollution, dust storms, grassland fires, and inadequate disposal of radioactive wastes often pose locally serious human health threats. Urbanization, soil erosion, desertification, and trade in endangered species are among additional concerns in China, Mongolia, Taiwan, Japan, and North Korea.

Climate. The climate of this region varies: arctic (or alpine) long-term cold in the southern and western Chinese mountains and Tibetan Plateau; temperate and continental in the central and northern hill areas and plains of China, the coastal plains of the Koreas, Japan and Taiwan; cold and very dry in the Gobi Desert; cold to temperate in the high northwestern plains and northeastern steppes of Mongolia and China; and humid tropical along coastal areas of eastern and southeastern China, Hong Kong, Macau, Japan, Taiwan, and southern South Korea. At several locations in this region, temperatures may range through as much as 25 - 30ºC within a single day. Among the greatest extremes on an annual basis are the Gobi and Taldimakan Deserts in China, where daytime temperatures in summer often are above 38ºC, and daily minimums in winter frequently fall below -34ºC. Annual precipitation for any particular country, area or site in East Asia varies across a very wide range and usually depends heavily on elevation, prevailing weather patterns, season, proximity to a major mountain range or large body of water, and sometimes even local topography. Actual average annual precipitation ranges from less than 10 mm in the Gobi Desert, to more than 2,500 mm in Hong Kong, Macau, and Taiwan. Monsoons bring severe storms and flooding, costing many lives every year in China, Japan, North and South Korea, and Taiwan. Very cold conditions, snow and related winter storms can claim many human lives every year in mountainous areas throughout this region, especially the western provinces of China, most of Mongolia, North and South Korea, and Japan.

Population and Culture. East Asia is home to almost 1.5 billion people; however, this population is concentrated in major cities and along the fertile river valleys and coastal plains. Population density for the whole region averages 130.6 persons per sq km, but it ranges from a low of only 0.25 persons per sq km in the southern Gobi Desert region to 6,800 persons per sq km in Hong Kong and more than 21,200 persons per sq km in Macau. The people of these countries can trace their origins back many centuries: over 900 years for the Mongolians, more than 3,750 years for the Chinese, and about 1,200 years for both the Japanese and Koreans. In nearly every country more than half of the people are of Chinese descent, with the exceptions of North and South Korea, and Japan. The principal religions are Buddhism, Taoism, Confucianism, Christianity, Islam, and Chondogyo (Religion of the Heavenly Way). Some mixture of Buddhism, Taoism and Confucianism is the preference of more than half of all people in every one of these countries except South Korea, China and North Korea. The two last-named nations are officially "atheist" and usually suppress religious expression to a large degree. Still, traditional religious, ethnic, and family traditions and customs strongly influence most people's daily lives, beliefs, and actions. Every nation in the East Asian region is more than 50% urbanized except China (which is 29% urbanized), and the people are on average more than 80% literate. Current life expectancy at birth ranges from a low of 67.3 years in Mongolia to a high of 80.6 years in Japan, and is at least 70 years in every country except Mongolia.

Sanitation and Living Conditions. Water is mainly drawn from surface sources throughout East Asia. Supplies in many places are inadequate, especially in the deserts and steppes of eastern Mongolia and northeastern China, in the uplands of most of western China and Mongolia, and in many isolated mountain valleys in China, North Korea, and Taiwan. These shortages affect more than 20% of the population of the whole region. Ground water reserves

have fallen significantly in much of China, Mongolia, and North Korea. In most large urban areas, inefficient treatment and inadequate, leaking, and poorly maintained distribution systems dispense contaminated water, mainly through public standpipes. In-house distribution is often available in modern dwelling units in large cities. Some piped water is supplied to a small proportion of rural sites, but most rural residents get their water from shallow wells, rain water catchment, and directly from other raw water sources. These conditions are ideal for the maintenance and rapid distribution of a wide variety of water-borne human pathogens. Municipal sewage systems exist only in major urban areas, and only a very small percentage of the total sewage is treated by such systems (estimated at less than 10% for China, North Korea, Mongolia, and Macau). Many domestic and industrial wastes are dumped untreated into open ditches and waterways. Pit latrines and septic tanks are found in many urban areas, but the most common method of excrement disposal is still bucket or cart collection. Garbage is seldom treated before disposal into surface water or onto the ground. Widespread surface water contamination and totally inadequate sewage treatment and waste disposal provide excellent conditions for the maintenance and direct spread of many pathogens and parasites of humans and domestic animals. These practices also ensure the attraction and maintenance of large populations of various parasites and disease vectors in places where people live. Plastics, packaging materials, and toxic substances are growing components of the waste stream in most countries in this region. In suburban areas, unprocessed industrial waste and garbage are often piled up. In rural areas, refuse is burned or disposed of indiscriminately. In industrialized areas, surface waters are also contaminated with chemical wastes, including high levels of heavy metals, cadmium, arsenic, complex organic chemicals, and petroleum products. These contaminants pose a threat of both acute and chronic poisoning to humans and domestic animals. Industries that pollute water sources include machinery or automobile manufacturing plants, power plants, and metallurgical, chemical, mining, and shipping facilities. Ground water contaminants include fertilizers, pesticides, and mining and industrial wastes. Many major rivers in East Asia carry heavy silt loads from soil erosion and deforestation, causing a large risk of silt-induced flood damage, especially in such places as the North China plain and the coastal plains of North and South Korea, Japan, and Taiwan. Coastal waters are frequently polluted by raw sewage, oil, and industrial waste discharges from polluted rivers. These materials can poison humans directly and kill many nontarget organisms, degrading terrestrial and aquatic environments, and reducing populations of fish and other organisms that are usually a significant portion of the population's diet. Severe blooms of certain marine organisms, known as "red tides," are associated with agricultural runoff and sometimes appear along coastlines, most recently in China, Japan, and Taiwan. These organisms kill massive numbers of fish. Air pollution levels near and in most major industrialized cities of East Asia are high by Western standards. Combustion by-products of coal have created some of the world's highest concentrations of particulates, sulfur dioxide, and benzopyrene. Cigarette smoking and coal-burning stoves can cause significant indoor air pollution as well. These pollutant concentrations are frequently greater than World Health Organization (WHO) guidelines (230 $\mu g/m^3$ daily maximum), and levels of sulfur dioxide are often much greater than WHO guidelines (150 $\mu g/m^3$ daily maximum). Chemical weapons left over from World War II, including mustard gas and lewisite, have been found in several provinces of China. Food sanitation practices in homes and commercial establishments throughout East Asia are generally inadequate by Western standards.

These conditions and practices all combine to ensure that a wide variety of food-borne and vector-borne pathogens are maintained and often spread rapidly to humans and domestic animals. A large portion of the human population of this region now lives in urban or suburban slums. Living conditions are primitive in many rural areas of China, Mongolia and North Korea. This means that people are routinely and directly exposed to contaminated water, untreated sewage and industrial wastes, air polluted by high concentrations of chemicals or particulates, and in some cases possibly even radioactive wastes (a current concern in Taiwan and North Korea). People are also living in close daily contact with many potential pathogens, parasites, disease vectors, and nuisance vermin that the water, sewage, and waste disposal problems attract, support and help spread. The recent and continuing high rates of urbanization in most of these countries, along with little or no oversight by government or public health officials, are causing ever-increasing numbers of people to live under unhealthful conditions, which in many major cities are steadily getting worse.

DIARRHEAL DISEASE

Gastrointestinal infections are highly endemic throughout East Asia and are the principal disease threats to military personnel deployed to the region. Bacillary dysentery has had a profound impact on military operations throughout history.

Fecal-oral transmission from person to person is common, but most infections are acquired from the consumption of contaminated food, water or ice. Filth flies can be important in the mechanical transmission of pathogens to food, food preparation surfaces and utensils. Fly populations sometimes reach very high levels during the summer in areas with poor sanitation. Strict sanitation and fly control can significantly reduce the risk of gastrointestinal infections. Cockroaches have also been shown to mechanically transmit gastrointestinal pathogens.

Bacteria and viruses causing diarrheal disease include: *Staphylococcus aureus*, *Clostridium perfringens*, *Bacillus cereus*, *Vibrio parahaemolyticus*, numerous serotypes of *Salmonella*, *Shigella* spp., *Campylobacter*, pathogenic strains of *Escherichia coli*, hepatitis A and E, rotaviruses, and other viral species. Infection with pathogenic protozoa, such as *Entamoeba histolytica*, *Giardia lamblia* and *Cryptosporidium* spp., is common, though bacterial pathogens account for most cases of diarrheal disease. Onset of symptoms is usually acute and may result in subclinical infections or severe gastroenteritis. *Shigella* infections can produce significant mortality even in hospitalized cases. Typhoid and paratyphoid fevers are also highly endemic and were a major cause of illness among Soviet troops serving in Afghanistan during the 1980s. Resistance of enteric pathogens to commonly used antibiotics can complicate treatment. Such resistance is very common in many parts of East Asia, including modern cities like Hong Kong, and bacterial populations with resistance to multiple antibiotics have been reported.

MOSQUITO-BORNE DISEASE*

Malaria transmission is limited to China and the Korean Peninsula. No significant risk of malaria occurs in the northern and western provinces of China. Malaria transmission occurs only in rural areas below 1,500 m. Some resurgence of malaria has occurred in southern provinces. *Plasmodium falciparum* occurs primarily if not exclusively in Hainan and Yunnan

Provinces. Yunnan Province, which borders Myanmar, Laos and Vietnam, has a large number of imported cases of malaria, including a high proportion of *P. falciparum*. Mixed infections are common. There is a low risk of vivax malaria in the eastern provinces of Jiangsu, Shandong, and Zhejiang, Shanghai municipality, the central provinces of Anhui, Hubei and Sichuan, and the southern provinces of Fujian, Guangdong, Guizhou, Hainan, Hunan and Jiangxi, as well as the Guangxi Autonomous Region. Sporadic cases of *P. malariae* are reported. North of latitude 33° N, transmission occurs from July to November; from latitude 33° N to 25° N, transmission occurs from May to December; south of latitude 25° N, transmission occurs year-round. Multidrug-resistant falciparum malaria occurs in southern and southeastern China, especially Yunnan and Guangxi Provinces, and Hainan Island. The highest levels of drug resistance have been reported from the areas bordering Myanmar, Laos and Vietnam. The Republic of Korea was declared malaria-free in 1979. However, vivax malaria re-emerged in 1993 when an outbreak occurred along the Demilitarized Zone (DMZ) bordering North Korea. Most cases have been acquired in areas in or near the DMZ, although some transmission has occurred in southern provinces of South Korea. Risk is limited primarily to Kyonggi-do and Kangwon-do Provinces. The endemic status of malaria in North Korea is unknown. At least 10 species of *Anopheles* mosquitoes transmit malaria in the region. Many of these are species complexes that are poorly understood. Insecticide resistance is widespread.

Periodic outbreaks of **dengue** caused by all 4 serotypes of the virus have occurred in China and Taiwan. **Dengue hemorrhagic fever** and **dengue shock syndrome** have been reported from both countries. Populations of the primary vector, *Aedes aegypti*, have greatly increased as a result of rapid and uncontrolled urbanization in many areas of East Asia. *Aedes albopictus* is an important vector in rural areas of the region. Dengue is a debilitating disease that would be a significant threat to military forces operating in the region.

Japanese encephalitis (JE) is a serious neurological disease that causes high morbidity and mortality throughout Asia. Periodic outbreaks of JE have occurred in every country of East Asia except Mongolia. The expansion of irrigation and rice growing in many areas has greatly increased populations of the primary mosquito vector, *Culex tritaeniorhynchus*, as well as other *Culex* vectors. However, the incidence of JE has decreased in most countries of the region due to extensive vaccination programs. JE remains highly enzootic in many parts of East Asia and is a threat to nonimmune military personnel. Effective vaccines limit the impact of this disease on military personnel operating in endemic areas.

Sporadic but irregular outbreaks of **chikungunya fever** occur in China and possibly other parts of East Asia. This disease is transmitted by *Ae. aegypti*. Like dengue, it is debilitating and can incapacitate large numbers of people in a short period. Due to its limited prevalence in East Asia, chikungunya fever is less of a threat than dengue.

There is evidence that **Sindbis virus** is circulating in China and Taiwan. Its enzootic status is unclear, but it represents little threat to military personnel due to the mild nature of the illness it causes and the apparently low prevalence of the virus in East Asia.

Bancroftian filariasis, caused by ***Wuchereria bancrofti***, and **Brugian filariasis**, caused by ***Brugia malayi***, once major public health problems in China, have been largely controlled in all 864 filariasis-endemic counties as a result of extensive public health programs. However, the primary vectors of Bancroftian filariasis, *Culex pallens* and *Cx. quinquefasciatus*, have become increasingly abundant as breeding sites have proliferated due to rapid urbanization and poor sanitation. Nocturnally periodic forms of *B. malayi* and *W. bancrofti* are currently endemic at low levels in southern and eastern China. There is a low risk of *B. malayi* transmission in the southern coastal provinces of South Korea, especially Cheju-do Island, where the primary vectors are *Aedes togoi* and *Anopheles sinensis.* Filariasis was last reported in Japan from the Ryukyu Archipelago and the Izu Schichto Islands but has probably been eradicated. Likewise, the last reports of Bancroftian filariasis in Taiwan were from the Pescadores, Kinmen (Quemoy), and Matsu Islands, but transmission probably no longer occurs. Serious medical complications result only from chronic infection; however, the first infection with these filarial worms can produce acute illness.

TICK-BORNE DISEASE*

Tick-borne encephalitis (TBE), primarily of the Far Eastern type, is focally distributed throughout China in ecological conditions that are favorable to the primary vector, *Ixodes persulcatus*, and small rodent reservoirs of the virus. During the 1990s, natural foci of TBE were reported in the Hunchun area of Jilin, China, where antibodies against TBE virus were detected in 12% of the sera of wild mice and 11% of the sera of the human population tested. Foci of **Russian spring-summer encephalitis** were also found in 4 counties of the Tianshan Mountains, Xinjiang. *Ixodes persulcatus* was collected in 18 counties of the Tianshan Mountains, as well as the Alatau, Taerbahati and Altai Mountains. In 1989, 2 strains of RSSE virus were isolated from *I. ovatus* ticks collected at 2700 m in the subtropical region of western Yunnan, China, near the Burmese border. TBE was first confirmed in Japan when the virus was isolated from an encephalitis patient in 1948. No further cases of TBE were identified in Japan until 1993, when a case was confirmed in a dairy farmer in Hokkaido, the northernmost of Japan's main islands. The virus was isolated from sentinel dogs, *I. ovatus* ticks, and rodents (*Apodemus speciosus* and *Clethrionomys rufocanus*) in 1995 and 1996 in Oshima, southern Hokkaido. These isolates were demonstrated to be closely related to RSSE virus. Cases of TBE have not been reported recently from Taiwan. The endemic status of TBE is unclear in North and South Korea. Cases have been reported historically, and competent tick vectors are abundant in many rural areas. The severe clinical disease produced by the virus of TBE in East Asia would be a serious concern to military medical personnel.

Lyme disease is an emerging disease in East Asia, and the epidemiological picture of the disease in the region is incomplete and confusing. Sporadic human cases of Lyme disease have occurred throughout Japan, caused by *Borrelia afzelii*, *B. garinii* and a new species of *Borrelia* isolated from *Ixodes ovatus* and named *B. japonica*. The Japanese strains of *B. afzelii* and *B. garinii* have unique molecular characteristics that distinguish them from European and Russian strains of these agents. Several new species of Lyme spirochetes have been isolated in Japan, but their role in human disease is not known. From 1987 to 1996, a survey was conducted in 60 counties and districts of 22 provinces in China. Endemic foci were discovered in 17 provinces, and

typical cases of Lyme disease were diagnosed in 11 provinces. Strains of *B. afzelii* and *B. garinii* were isolated from ticks and small mammals, and these strains seemed more closely related genetically to Japanese strains than to strains from Europe. Numerous isolations were made in northeastern China and Inner Mongolia. Based on these studies, Lyme disease is undoubtedly enzootic in Mongolia. Several species of Lyme *Borrelia* have been isolated from ticks and small rodents in South Korea, including *B. afzelii* and *B. garinii* (both isolated from *I. persulcatus*), *B. valaisiana* (isolated from *I. nipponensis*), and a recently identified but unnamed strain isolated from *I. granulatus* and *Apodemus agrarius* mice collected in Haenam. However, only 3 human cases had been confirmed as of 1999. These studies suggest that Lyme disease is probably enzootic in North Korea as well. Spirochetes were isolated from 6 species of wild and peridomestic rodents in Taiwan during the mid 1990s. The highest infection rates were found in the brown country rat, *Rattus losea*. Serological and PCR analysis indicated that all of these isolates were genetically related to *B. burgdorferi* sensu strictu. This was the first evidence of Lyme disease in Taiwan, where the first human case was reported in 1998. Military personnel would be at high risk of exposure to ticks and tick-borne disease.

Crimean-Congo hemorrhagic fever infects domestic animals and is widely distributed in discrete foci in agricultural and rural areas. Human cases are sporadic. The most recent outbreaks have occurred in China. The disease can be contracted by the bite of infected *Hyalomma* ticks, but most human cases result from exposure to secretions or blood from infected animals or humans. Medical workers treating patients are at high risk of becoming infected. Clinical symptoms can be severe, with mortality rates up to 50%.

Boutonneuse fever (also termed Indian tick typhus and Siberian tick typhus), caused by *Rickettsia conorii* and closely related organisms and transmitted by the brown dog tick, *Rhipicephalus sanguineus*, and other ixodid ticks is focally distributed, primarily in China, Japan and Mongolia. Several species of *Rickettsia* in the spotted fever group are enzootic in East Asia. *Rickettsia sibirica* predominates in China and Mongolia, while *R. japonica* is the causative agent of spotted fever in Japan. The risk of infection with *R. conorii* is elevated in cities and villages with high populations of tick-infested dogs.

Most cases of **sennetsu fever** caused by *Ehrlichia sennetsu* have been reported from western Japan. However, other species of *Ehrlichia* may be causing human **ehrlichiosis** in East Asia. Isolates of *E. chaffeensis* or a closely related species were made from ticks collected in Yunnan and Fujian Provinces in southern China. A granulocytic *Ehrlichia* was isolated from *Ixodes persulcatus* collected from a forest area of Heilongjiang Province in northeastern China. At least 2 species (*E. canis* and *E. platys*) that cause canine ehrlichiosis are widely distributed in East Asia. A new species of *Ehrlichia*, *E. muris*, was isolated from the mouse, *Eothenomys kageus*, collected in Aichi Prefecture in Japan in the early 1990s. *Ehrlichia muris* has not been associated with human disease, although human antibodies to *E. muris* have been found in residents of metropolitan Tokyo. Strains of *Ehrlichia* closely related to *E. chaffeensis* have also been isolated from *Ixodes ovatus* in Japan. Their role in human ehrlichiosis in the region is unknown.

Q fever is an acute, febrile rickettsial disease contracted primarily by inhalation of airborne pathogens or contact with secretions of infected domestic animals. Transmission by ticks to humans is possible but rarely, if ever, occurs. Serological surveys indicate that Q fever is widespread throughout East Asia and infects a wide variety of wild and domestic animals, especially sheep and goats. Military personnel should avoid exposure to sheep, goats, cattle and other domestic animals and should not sleep or rest in animal shelters.

Sporadic cases of **tick-borne relapsing fever**, caused by *Borrelia recurrentis*, are also reported throughout the region. The disease is enzootic in rocky, rural areas where livestock are tended and vector soft ticks, *Ornithodoros* spp., are found. Its military threat is minimal.

Tularemia outbreaks have been reported from China, Japan and Mongolia. The best epidemiological data for tularemia are from Japan. A total of 1,374 cases were reported in Japan between 1924 and 1996. About 94% of all cases were attributed to contact with diseased hares. Although tick-borne transmission is common in North America, tick-borne cases have historically been infrequent in East Asia. Only 1.2% of the cases were arthropod-borne, although the rate of arthropod-borne tularemia has been increasing since 1980. The disease occurs between May and October. Most arthropod-borne cases have been reported from northeastern Honshu, the main island of Japan. Cases have been reported from numerous areas of Mongolia and China. In the mid 1980s, up to 14% of the people tested in the Tacheng District of Xinjiang Autonomous Region had antibodies to *Francisella tularensis.* Two percent of the people tested and 19% of sheep in Ali Prefecture, Tibet, were seropositive in the early 1990s.

MITE-BORNE DISEASE*

Scrub typhus, caused by the rickettsia *Orientia tsutsugamushi*, is focally distributed throughout the region from coastal lowlands to over 3,000 m in the Himalayan Mountains. The disease is transmitted by chigger mites of the genus *Leptotrombidium*, subgenus *Leptotrombidium*, that are primarily associated with rodents of the genus *Rattus*. Scrub typhus is prevalent in disturbed habitat characterized by secondary scrub vegetation and grasses. During World War II, scrub typhus was one of the leading causes of morbidity in military personnel in the Asia-Pacific area. Although the incidence of human infection in East Asia is not precisely known, the disease is enzootic in all countries of the region and represents a significant threat to military forces in the field.

LOUSE-BORNE DISEASE*

Epidemic typhus may still be endemic among poor people living in rural Mongolia, North Korea and northern China. Declining sanitary and living conditions caused by the failing North Korean economy have increased the likelihood that this and other vector-borne diseases may re-emerge. Body lice are not uncommon in colder parts of East Asia.

Sporadic cases of **louse-borne relapsing fever** have also been reported from the region, and, like epidemic typhus, it is a winter disease.

FLEA-BORNE DISEASE*

Murine typhus is a rickettsial disease similar to louse-borne typhus but milder. It is enzootic throughout the region in domestic rats and mice and possibly other small mammals. Infected rat fleas, usually *Xenopsylla cheopis*, defecate infective rickettsiae while sucking blood. Airborne infections can occur. Sporadic human cases have been reported throughout East Asia.

Enzootic **plague** is widespread in rural areas of China and Mongolia. Most recent outbreaks in humans have resulted from hunting and skinning marmots, an important reservoir of the disease. *Xenopsylla cheopis* is not highly prevalent in East Asia, and a large number of other flea species and small mammals are involved in the complex cycle of wild rodent plague.

SAND FLY-BORNE DISEASE*

Cutaneous leishmaniasis (CL) is moderately or highly endemic in China and Mongolia. Two species of *Leishmania* cause skin lesions in the region. The less severe and rurally distributed *Le. major* is a parasite of desert and dry jungle rodents, especially gerbils such as *Rhombomys opimus* and *Meriones meridianus*. Cutaneous leishmaniasis, also caused by *Le. major* and called "rural"or "wet" cutaneous leishmaniasis or zoonotic cutaneous leishmaniasis, is present in small villages and rural areas of East Asia, especially China and Mongolia. The suspected sand fly vectors of *Le. major* in East Asia include *Phlebotomus alexandrei, P. andrejievi*, *P. caucasicus*, *P. chinensis*, *P. mongolensis* and *P. smirnovi*. The second type of cutaneous leishmaniasis is caused by *Le. tropica* and called "urban" or "dry" cutaneous leishmaniasis or anthroponotic cutaneous leishmaniasis. *Leishmania tropica* is usually a parasite of man in urban environments and is transmitted primarily by *P. chinensis*. Man is the principal reservoir, but wild dogs and raccoon dogs, *Nyctereutes procyanoides*, have been found naturally infected.

Visceral leishmaniasis (VL), caused by two parasites, *Leishmania donovani* and *Le. infantum*, is a severe systemic disease and important threat to military personnel. VL caused by *Le. donovani* is spread by three anthropophilic sand flies (*P. alexandrei*, *P. caucasicus* and *P. mongolensis*), primarily in northern China and southern Mongolia. Man is believed to be the reservoir of *Le. donovani* in East Asia. VL caused by *Le. infantum* is widely endemic in China, from cities like Beijing to rural areas. Suspected vectors of *Le. infantum* in East Asia are *P. chinensis*, *P. longiductus*, *P. sichuanensis*, and *P. smirnovi*. The most common reservoirs of *Le. infantum* are believed to be domestic dogs and wild canines, primarily raccoon dogs, *N. procyanoides*, and foxes. Transmission of leishmaniasis occurs during the warmer months of April through October, coinciding with the activity of vector sand flies. The distribution of sand flies and the diseases they carry is often very focal because of the specialized habitats required by sand fly larvae and the limited flight range of adults. The incidence of leishmaniasis has been rapidly increasing in some areas as a result of the cessation of residual spraying for malaria control. No autochthonous (acquired within the country) cases of CL or VL are known from Taiwan, Japan, Macau, Hong Kong, or Korea. However, the close proximity of Macau, Hong Kong and North Korea to endemic areas of leishmaniasis make autochthonous transmission possible.

RODENT-BORNE DISEASE

Hantaviral diseases are an emerging public and military health threat. Field rodents are reservoirs for several closely related viruses that can be transmitted to humans exposed to airborne pathogens from dried rodent urine and feces. Serological evidence of hantaviral infection has been detected in humans or wild animals in every country of East Asia. At least 3 serotypes of hantavirus that cause clinical disease in humans are present in the region. A severe form of the disease referred to as hemorrhagic fever with renal syndrome (HFRS) is caused by Hantaan virus and is associated with *Apodemus* field mice in open field or unforested habitats. Death rates often exceed 10%. A milder disease, caused by Puumala virus, is associated with voles (*Clethrionomys* spp.) in woodland or forest-steppe habitats. The Seoul serotype infects *Rattus norvegicus*, and risk of infection occurs when living or working in dusty rat-infested buildings. Over 50,000 cases of HFRS are reported annually in China and at least 1,000 cases occur annually in South Korea.

Leptospirosis should be considered enzootic in most countries of East Asia. The spirochete is transmitted when abraded skin or mucous membranes are contacted by water contaminated with urine of infected domestic and wild animals, especially rats. Military personnel would be at high risk of infection from this disease. Troops should never handle rodents and should not sleep or rest near rodent burrows or swim or bathe in stagnant pools or sluggish streams.

SNAIL-BORNE DISEASE

Although fewer than 1 million people are currently infected with schistosomes of the *Schistosoma japonicum* complex, **schistosomiasis** remains a major public health threat in China. Only *S. japonicum* has been described, although identification of unique Chinese strains based on molecular genetic data suggests emergence of new members of this species complex. The major endemic foci are in the marsh and lake regions of southern China and the Yangtze River Basin (Hubei, Hunan, Jiangxi, and Anhui Provinces), which account for 86% of the cases. Over 100 million people are at risk of infection in these schistosomiasis-endemic areas. The environmental changes caused by construction of the Three Gorges super dam on the Yangtze River may dramatically increase habitat for *Oncomelania* snails, the intermediate hosts of *S. japonicum*.

CONJUNCTIVITIS

Bacterial and viral **conjunctivitis** is very common in East Asia and has epidemic potential. Enterovirus type 70 has been implicated in some outbreaks. Trachoma is endemic in the warmer southern areas of China. Transmission is normally through contact with secretions of infected persons or contaminated articles. Eye gnats and flies can mechanically transmit these pathogens. Several species of eye-frequenting moths, primarily in the family Noctuidae, are known from East Asia. These moths feed on the lacrimal secretions of wild or domestic animals as well as humans. They may also play a role in the transmission of ocular pathogens.

VENOMOUS ANIMALS

Thirty-three species of poisonous terrestrial snakes and 23 species of venomous sea snakes representing 5 families are found in the East Asian region. Some, such as the king cobra which

can reach 18 feet in length, can be very intimidating and possess lethal venoms. The Okinawa habu, *Trimeresurus flavoviridis*, readily enters houses. Snakebite is a serious risk in the region. Military personnel should be thoroughly briefed on the risk and prevention of snakebite, as well as the steps to take immediately after snakebite. Effective snake antivenins are available. **Scorpions, centipedes** and **widow spiders (*Latrodectus* spp.)** are common in many parts of East Asia. *Scolopendra* species of centipedes can attain a length of over 25 cm and inflict a very painful bite. *Mesobuthus eupeus* is the only notably toxic scorpion in the region and may cause a variety of painful symptoms in adults, including neurological involvement. Death is usually limited to small children and the elderly. Scorpion stings rarely require hospitalization, although envenomization by widow spiders can be life threatening. Antivenins are available. Troops should be warned not to tease or play with snakes and scorpions.

*** A properly worn Battle Dress Uniform (BDU) impregnated with permethrin, combined with use of extended duration DEET on exposed skin, has been demonstrated to provide nearly 100% protection against most blood-sucking arthropods. This dual use of highly effective repellents on the skin and clothing is termed the "DoD arthropod repellent system." It is the most important single method of protecting individuals against arthropod-borne diseases. Permethrin can also be applied to bednets, tents and screens to help prevent disease transmission by insects. The proper use of repellents is discussed in TIM 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance.**

VECTOR-BORNE DISEASES IN EAST ASIA (+ = present; ? = uncertain).

Diseases	China	Japan	Mongolia	North Korea	South Korea	Taiwan
malaria	+			+	+	
dengue	+					+
chikungunya fever	+			?	?	?
Japanese encephalitis	+	+		+	+	+
tick-borne encephalitis	+	+		?	?	
ehrlichiosis	?	+				
Crimean Congo hemorrhagic fever	+		?			
boutonneuse fever	+	+	+	?	?	?
Q Fever	+	+		?	+	
relapsing fever (tick-borne)	?			?		
tularemia	+	+	+			
scrub typhus	+	+	?	+	+	+
plague	+		+			
murine typhus	+	?	+	+	+	+
epidemic typhus	?		?	?		
relapsing fever (louse-borne)	?		?	?		
cutaneous leishmaniasis	+		+			
visceral leishmaniasis	+		+			
schistosomiasis	+					
filariasis	+				+	
Lyme disease	+	+	?	?	+	+
leptospirosis	+	+				
hantaviral disease	+	+	+	+	+	+

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A. CHINA.

1. Geography. China is slightly larger than the U.S. and has a total land area of approximately 9.3 million sq km. Its greatest east-west distance is 5,440 km from its northeastern provinces adjacent to Russian Siberia to the mountainous areas of Tibet bordering Nepal and India. China comprises three major geographic regions: (1) In the southwest, the Plateau of Tibet, which is located in both Xizang (Tibet) and Tsinghai, has an average elevation of 4,000 m above sea level. The highest point in China is Mount Everest at 8,850 m in southern Tibet. Most of China's remaining forests are found in the southwest. The westernmost area (Chiang-t'ang) has an average elevation of about 5,000 m. This region includes Turpan Pendi, the lowest point in China (-154 m), which is isolated in a deep valley between mountain ranges in the far north-central part of Xinjiang Province. The deserts and mountains that fill the western half of China are so forbidding that less than 10% of the population lives there. (2) A highland area with elevations between 900 and 1,800 m includes the Mongolian and loess plateaus in the Tarim and Upper Szechwan Basins and the Yunnan-Kweichow highlands. (3) The easternmost region, extending from the Yunnan-Kweichow highlands to the Yellow Sea, lies less than 450 m above sea level. It contains the country's largest lowland areas, the Manchurian and North China Plains and the Lower Szechwan Basin.

China's three main rivers, the Huang He (Yellow River), Yangtze, and Xijiang (West River), have their origins deep within the remote territory west of the mountains but flow through the more level eastern regions in a sluggish manner. The rivers quickly swell in the spring as a result of rains brought by the southeastern monsoon. Overflowing their banks, they spread rich silt on the surrounding lands. The immense quantities of silt carried by the Huang He River give it the name "Yellow River" and have built up a river bed over the years that is higher than the surrounding land. When the Huang He floods, the results can be catastrophic. As a result of deforestation, flooding along the Yangtze river during 1998 left 12 million Chinese homeless and caused nearly $5 billion in damage. Annual variations in rainfall in the central and eastern regions of China cause periodic crop failures by either drought or flood. The Three Gorges Dam, now being constructed on the Yangtze, is an enormous project designed to control the waters of China's longest river. It will displace over a million people. The development of the Three Gorges Dam will increase marshlands and irrigation in areas currently free of schistosomiasis. The potential for the spread of schistosomiasis and other vector-borne diseases is a major public health concern.

China shares borders with 15 different countries. These borders range from 72 km with Afghanistan to more than 3,600 km with Russia. China also has about 14,500 km of eastern and southeastern coastline on four major bodies of water: the Sea of Japan, Korea Bay, East China Sea, and South China Sea. Rugged mountains make travel difficult in many areas, especially in the far north and west. Primary land uses include: 10% arable, 43% permanent pasture, 14% forests and woodlands, and 33% other (e.g., urban, roads, etc). Since 1949, China has lost more than 20% of its agricultural land to erosion, desertification, and economic development. Severe water shortages, water pollution, and contamination of agricultural land from raw sewage and industrial wastes are threats to human health. People also face environmental health threats from

high altitude and extreme temperatures. Earthquakes, mudslides, floods, and typhoons are frequent events. The degree of risk in any location is related to elevation, ruggedness of terrain, season, and regional or local weather.

2. Climate. China's diverse climate, which varies from tropical in the south to subarctic in the north, is influenced by Pacific and Siberian air masses. Except at extreme high elevations, hot and humid summer weather is typical throughout China, when moist tropical Pacific air masses bring monsoon rains to the south and east. The hillier and more mountainous areas found in southern China have wetter, warmer temperatures that produce thick growths of forest on uncultivated land. Northern summers also are very rainy. Winters are dominated by bitterly cold, dry Siberian air masses that often penetrate to the southern provinces. Little precipitation falls during the colder months, when clear days with low humidity and temperatures are common. During late winter and spring, strong north winds sweep across northern China. These winds stir up dust storms, causing haze. The most extreme temperatures occur in the Gobi and Taldimakan Deserts, where summer daytime temperatures regularly exceed 38ºC and winter daily lows fall to -34ºC. Tibet and Manchuria also have long, cold winters. Much of China's land is arid or semi-arid, especially in the north and west. The southeastern mountains have the highest rainfall, often more than 1,500 mm annually. The central highland areas receive about 1,000 mm of rainfall in the east and 300 mm in the west. Annual rainfall in the Tibetan Highlands is about 200 mm, and only 10 mm or less in the western and northern deserts. Typhoons along the lower coastal areas occur mostly in August but have occurred as late as December. The eastern coastal areas are vulnerable to floods, earthquakes, and marine calamities.

During 2001, China suffered one of its worst droughts in two decades. The drought stretched across 17 provinces and threatened the Baiyangdian marshlands, northern China's largest freshwater lake system. Less than 20% of the wastewater from farms and cities upstream is treated before it flows into Baiyangdian. With less water, the Baiyangdian lakes have become among the most polluted in China.

Shanghai - Eastern Lowlands **(elevation 7 m)**

Mean Daily Temperatures (ºC)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	7	8	12	18	25	27	32	32	27	23	17	11
MINIMUM	0	1	4	10	15	19	23	23	18	13	7	2

Monthly Precipitation (liquid equivalent)

MEAN (mm)	48	58	84	94	94	180	147	142	130	71	51	36

Lhasa - Southwestern Highlands **(elevation 3,685 m)**

Mean Daily Temperatures (ºC)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	8	9	12	17	21	24	24	23	22	17	13	9
MINIMUM	-9	-6	-2	3	7	11	11	11	9	3	-4	-8

Monthly Precipitation (liquid equivalent)

MEAN (mm)	5	5	13	23	106	196	510	368	216	25	10	4

Kashi -Northwestern Highlands **(elevation 1,309 m)**

Mean Daily Temperatures (ºC)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	1	6	13	22	27	32	33	32	28	22	12	3
MINIMUM	-11	-7	2	9	14	18	20	19	14	6	-2	-8

Monthly Precipitation (liquid equivalent)

MEAN (mm)	15	3	18	5	8	5	10	8	8	8	5	8

3. Population and Culture. China's population, estimated in July 2000 to number more than 1.26 billion, represents about one-fifth of the world's population. Some experts think the population may actually be higher. Population growth is China's fundamental environmental issue, underlying all others. More than 70% of China's large cities and 50% of the country's total population are located in the eastern coastal region. Population density in this area varies from 2 persons per sq km to >770 persons per sq km. Over 30 cities have populations that exceed 1 million. In central China, Beijing has a population density of 27,600 persons per sq km. Parts of the western highlands are virtually uninhabitable and have population densities of <10 persons per sq km. The thinly scattered people of Tibet, Xinjiang and Manchuria have traditionally relied on animal husbandry for their livelihood. At least 20% of the population lives below the poverty line. Unemployment is estimated at 30%. Economic development is China's top priority, and the government is prepared to risk enormous environmental damage and levels of pollution in return for economic growth. The government's "Western Big Development" initiative is focused on the western provinces that account for half of China's land and contain the country's most important oil, natural gas and mineral reserves. Many inhabitants of China's western region are members of restive Tibetan and Islamic minority groups who have

not shared in the rising prosperity of China's coastal areas. Life expectancy at birth is 71.4 years.
China is about 29% urbanized, and 78% of the people are literate. China's urbanization rate is rapidly increasing (at least 4% a year since 1980) and is projected to reach 45% by 2010. China has one of the world's oldest civilizations, dating to the Shang dynasty established in 1766 B.C. The country's ethnic make-up is 91.9% Han Chinese and 8.1% other (Zhuang, Uygur, Hui, Tibetan, etc.). Officially, China is an atheist nation. Confucianism, Taoism, Buddhism, Islam and Christianity are intermixed, although religious expression was severely suppressed in the past by the communist government. In recent years, antireligious pressures have waned.

4. Sanitation and Living Conditions. Half of China's population draws its drinking water from surface sources that often fail to meet even industrial-use quality because of pollution. Water supplies in much of western and north-central China are inadequate, and most of China's water is in the south below the Yangtze River. So much water is drawn from the Yellow River in northern China that it fails to reach the Bo Hai gulf several weeks each year. Chronic water shortages affect nearly half of China's 700 cities, and in some cities the reduction of groundwater is a serious problem. In Beijing, groundwater levels were reportedly 5.52 m lower than normal in the early 1980s and now are dropping more than 1 m annually. The water table beneath the North China plain fell an average of 1.6m during the mid-1990s as cities, factories and farmers increased their demand for water. In large urban areas, inefficient treatment and inadequate, leaking distribution systems provide contaminated piped water, mostly through public standpipes. In-house distribution occurs mostly in modern dwelling units in larger cities. Piped water is reportedly supplied to rural areas in Yunnan, Hebei, Hubei, and Jiangxi Provinces and Inner Mongolia. Most rural residents get water from shallow wells, rain water catchment, and other raw water sources. Studies have shown that the availability of piped water reduces the likelihood that rural residents will come into contact with water containing the snail intermediate hosts of schistosomes. The incidence of disease declines as a result.

Municipal sewage systems exist only in major urban areas, but even there only 6% of sewage is treated. Most domestic and industrial wastes are dumped untreated into open ditches and waterways. While pit latrines and septic tanks are found in urban areas, the most common method of excrement disposal is by bucket or cart collection. Night soil is widely used to fertilize crops. Nationally it is estimated that only 7% of garbage is properly discarded. Widespread water contamination and inadequate sewage treatment and waste disposal contribute to the spread of many human pathogens and the breeding of arthropod vectors and rodents. Plastics, package materials, and toxic substances are growing components of the waste stream. In northern China, discarded food and ash residue from burned coal and food wastes reportedly constitute a majority of wastes. In suburban areas, unprocessed industrial waste and garbage accumulate in piles. In rural areas, refuse is burned or disposed of indiscriminately. Most surface water is heavily contaminated with raw sewage. In industrialized provinces (mainly in southeast China and coastal areas), surface water sources are also contaminated with chemical wastes, including high levels of heavy metals, cadmium, arsenic, cyanide, phenols, and petroleum products. Typical industries that pollute water sources include paper, asbestos, cement, leather, metals, chemicals, and shipping. Eighty percent of China's rivers are so

polluted that they no longer support fish. Groundwater contaminants include fertilizers, pesticides, and mining and industrial wastes. All major rivers of eastern China carry heavy silt loads from soil erosion and deforestation. Consequently, there is a high risk of silt-induced flood damage on the North China plain, particularly in the Huang He and Yangtze river basins. Severe blooms of marine organisms, known as red tides, have appeared along coastlines, most recently along the coast of Guangdong Province, killing massive numbers of fish. Food sanitation practices in homes and commercial establishments throughout China are inadequate by Western standards, with the result that risk of food- and water-borne pathogens is high. From 1988 to 1992, the Chinese Ministry of Health conducted a nationwide survey of nearly 1.5 million people to determine the incidence and prevalence of parasitic helminths. Some 707 million Chinese (62.6% of the population) were estimated to harbor one or more parasites. Prevalence was highest in the Yangtze River valley provinces. All intestinal helminths were linked to food-borne infections, which in China are caused by the common agricultural practice of using uncomposted human manure for fertilizing vegetable crops. The incidence of some food-borne parasites such as trichinosis is increasing. China is undergoing major social changes due to economic reforms, but in some rural areas access to healthcare has not improved. China’s cities have some of the worst air pollution in the world due to the almost exclusive use of coal to generate electricity and heat homes. Chronic lung diseases are a leading cause of death.

China’s arable land is disappearing at a rapid rate. According to an analysis of satellite photos in the late 1990s by the U.S. National Intelligence Council, China was losing 500,000 hectares of farmland a year. The NIC study concluded that China will soon not be able to feed its growing population and by 2025 will need to import 175 million tons of grain.

B. HONG KONG.

1. Geography. Hong Kong has a total land area of 1,042 sq km, including the Kowloon peninsula on the Chinese mainland and more than 200 islands. It is about six times the size of Washington, DC, and consists of three parts. First is the island of Victoria (or Hong Kong), on the north side of which is the city of Hong Kong. Second is the small area known as Kowloon, at the tip of a peninsula jutting from the Chinese mainland toward Victoria. Kowloon is connected by rail with the Chinese city of Guangzhou (Canton). The third part comprises the New Territories, which extend northward from Kowloon to the Chinese border and also include some islands in the waters around Victoria. Most of Hong Kong consists of hills and low mountains, but there are enough level lands in the New Territories for significant agricultural production. The highest point is 958 m at Tai Mo Shan, on Lantau Island. Hong Kong shares a 30 km border with China on the north, and is bordered by the South China Sea on the east, south and west. It has limited natural resources and raw materials. Currently, all of its potable water and energy resources must be imported from mainland China. Primary land uses include: 6% arable, 1% permanent crops, 1% permanent pasture, 20% forests and woodlands, and 72% other (mostly urban development). Hong Kong was a British Crown Colony from 1842 to 1997, when it became a Special Administrative Region (SAR) of China. The population is mainly of Chinese descent and is highly urbanized and literate. Hong Kong has 34 km of railways, 1,831 km of roads, and 3 airports. It is one of the world’s busiest seaports and is a center of world

travel and trade, handling nearly 45% of mainland China's foreign commerce. Consequently, it is at high risk of having a wide range of pathogens, vectors, parasites, and pests introduced in ships, airplanes, or by diseased humans or their pets and possessions. The density of the human population could facilitate the rapid spread of an introduced infectious or vector-borne disease.

2. Climate. Because it is surrounded by ocean and located just south of the Tropic of Cancer, Hong Kong has a tropical monsoon climate that is hot and rainy from spring through summer, warm and sunny in fall, and cool and humid in winter. There are occasional cold spells in winter, but snow or frost are almost never seen, even at the highest elevations. Although dry, the months of February to April are cloudy, with an average of only 3 to 4 hours of sunshine per day, compared to 6 to 8 hours per day during July through December.

Hong Kong (elevation 33 m)

Mean Daily Temperatures (ºC)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	18	17	19	24	28	29	31	31	29	27	23	20
MINIMUM	13	13	16	19	23	26	26	26	25	23	18	15

Monthly Precipitation (liquid equivalent)

MEAN (mm)	33	46	74	137	292	394	381	367	257	114	43	31

3. Population and Culture. With its transformation from a fishing village to a major international city, Hong Kong has become the commercial hub of East Asia and a melting pot of Oriental and Western culture. Hong Kong has an estimated population of 7.12 million, which is 94% urbanized and 92% literate. Overall population density is very high, at 6,829.5 persons per sq km. Both Hong Kong and its people are prosperous, and few are officially considered to live below the poverty line. More than 40% of the work force is employed in services, while just over 9% is employed in manufacturing. The population of Hong Kong is 95% Chinese and 5% other. Local cultural practices are diverse, reflecting various Chinese traditions as well as European (especially British) customs. About 90% of the population practices an eclectic mix of eastern and local religions, and about 10% follow Christianity. Life expectancy at birth is 79.5 years.

4. Sanitation and Living Conditions. Despite rising standards of living over the last 2 decades, food-borne disease remains a serious public health problem. All potable water must be imported from China. These lines have occasional breaks, pressure drops, or similar problems, resulting in risk of contamination. Backup systems either do not exist or are very limited. Drinking water in urban and resort areas of Hong Kong is purified and chlorinated. Elsewhere the risk of food or water-borne illness is significant. Treatment and disposal of human waste is

generally adequate, but a small portion of the population (especially those living on boats) routinely discards raw sewage or other wastes directly into surface water. Raw shellfish have been a common source of outbreaks of hepatitis A. Some industries accidentally or intentionally release chemical wastes into the harbor or onto nearby surfaces, where they enter harbor waters through runoff. At one time, there was so much floating debris in Victoria Harbor that the city had to send out scavenging boats to collect it, for fear of losing the tourist trade that was the city's second leading source of income. In 1995, the boats collected 17 tons of floating refuse every day. A modern sewage system was being constructed in the late 1990s, but it will spare only the harbor. The system's outflow pipes will instead contaminate the nearby ocean waters that are already overstressed by pollution from Guangdong's Pearl River. Historically, attempts to limit the numbers of automobiles bought and brought into Hong Kong have been largely ignored. Affluent citizens are willing to pay high tariffs for such luxuries. Air pollution standards are not uniformly enforced, and both light industries and automobile exhaust sometimes cause locally significant air quality reduction that may induce or worsen acute or chronic respiratory problems.

C. MACAU.

1. Geography. Macau is a former Portuguese enclave on the southern Chinese coast. It is surrounded by the South China Sea and located just south of the Tropic of Cancer. With a total land area of about 21 sq km, it is only about 0.1 the size of Washington, DC. Macau is almost totally urban, with a mere 2% of land in permanent crops and the remaining 98% in urban uses. It consists of the narrow Macau Peninsula on the Chinese mainland, attached by bridges and causeways to two nearby islands, Taipa and Coloane. The terrain is generally flat, and the offshore waters are muddy with silt carried by the Zhujiang River. The highest point in Macau is Coloane Alto at 174 m. Colonized by the Portuguese in 1557, Macau became a Special Administrative Region (SAR) of China on December 20, 1999. Under a major Chinese - Portuguese aid project, a new international airport has recently been built on a reclaimed site just east of Taipa. Macau is heavily dependent on China and other foreign sources for raw materials, energy, food, fresh water, most manufactured goods and tools, and even for most of its labor. Its economy is based on gambling and tourism, and Macau has historically been characterized as stagnant, corrupt, and bureaucratically inefficient. Gang violence has been a problem in recent years. Macau depends heavily on cheap Chinese labor and has become a major exporter of a wide variety of inexpensive finished goods, from textiles to fireworks and artificial flowers.

2. Climate. Macau's climate is subtropical, with a summer monsoon and cool, humid winters. Spring and summer are generally hot and rainy, while fall is usually warm and sunny. Average daily high and low temperatures and monthly precipitation are nearly identical with those of Hong Kong, which is located only 27 km due east. There are occasional cold spells in winter, but no snow or frost have ever been reported. The months of February through April are dry and cloudy, averaging 3 to 4 hours of sunshine per day, compared to 6 to 8 hours per day during July through December. In some areas, the high population density may make it seem much hotter

and more humid than it really is. Macau's inhabitants occasionally face serious threats from severe typhoons, local storms and related flooding.

3. Population and Culture. Macau has an estimated total population of 0.45 million and an average population density of more than 21,200 persons per sq km, one of the highest in Asia. Ethnically, the population is about 95% Chinese, and 5% Macanese and others. Religious preferences are 50% Buddhist, 15% Roman Catholic, and 35% other. The population is about 99% urbanized and 90% literate. Cultural practices and customs reflect the traditional Chinese heritage and Buddhist religion of the people. Average life expectancy at birth is 81.6 years.

4. Sanitation and Living Conditions. Nearly all Macau's fresh water is imported through pipelines from the Chinese mainland. There are occasional breaks, leaks or malfunctions in the lines, pumps, or holding tanks, which allow varying degrees of contamination. Most human sewage is adequately treated. However, old facilities and inadequate maintenance result in occasional discharge of wastes directly into surface waters or onto ground surfaces near the water. In some crowded urban areas, people often dispose of human or other wastes directly into or near surface water. Outbreaks of food or water-borne diseases are common. Large numbers of international tourists, combined with corrupt bureaucratic procedures, inadequate customs inspections and poor medical surveillance, are conducive to the introduction of pests, vectors or pathogens. Macau's high population density could facilitate the spread of infectious or vector-borne diseases to epidemic levels.

D. JAPAN.

1. Geography. The archipelago of Japan includes four major islands (Hokkaido, Honshu, Kyushu, and Shikoku) and more than 3,000 smaller islands and islets, including the Ryukyu Islands south of Kyushu. These islands total approximately 374,744 sq km of land (a little smaller than California). Rugged mountain ranges run the length of the larger islands, which separate the Pacific Ocean from the Sea of Japan. The mountains make travel difficult in the interior. Although most mountain peaks are only a few hundred m in elevation, 15 exceed 3,000 m. The highest point in Japan is Mt. Fujiyama at 3,776 m. The lowest point is Hachiro-gata at -4 m. Japan's coastline varies from rocky, deeply fragmented and fractured to flat shores with dunes; it is about 29,751 km long and borders the Sea of Japan, the Philippine Sea, the East China Sea, and the Pacific Ocean. The mountains leave little level space; only about 15% of the total land area is level and much of the only large plain is occupied by the busy capital of Tokyo. Japan has limited natural resources, so most raw materials, fuel, and food must be imported. Only small plots of land are cultivated. Land uses include: 11% arable, 1% permanent crops, 2% permanent pasture, 67% forests and woodlands, and 19% other. Japan has more than 23,600 km of railways, over 1,152,000 km of highways, 171 airports, and over 20 active seaports. The entire country is geologically unstable and subject to frequent and sometimes violent earthquakes. About 1,500 seismic events occur annually. Tsunamis caused by these tremors pose an additional risk to humans in coastal areas. Thermal pressures from deep in the earth escape periodically through the many volcanoes that are interspersed among the mountains. Occasionally, severe typhoons cause serious damage, flooding and loss of lives.

2. Climate. Japan's climate is generally humid and temperate; however, significant seasonal and geographic variations result in subtropical conditions in the south and cool temperate conditions in the north. The high elevations have much lower temperatures than the coastal areas. Storm severity and snow accumulation are greatest in the northwest. During winter, the Pacific coast experiences much less precipitation and clearer skies. On Hokkaido, Japan's northernmost major island, mean daily winter temperatures are approximately -2.9°C, compared to 2.4°C in Tokyo. Throughout Japan, the summer and fall months bring high temperatures, high humidity, and two periods of heavy rainfall (June to July and during Japan's typhoon season, September through October). Both rainfall periods include dense sea fog that reduces visibility, while the typhoon season frequently brings damaging winds and heavy rains.

Tokyo (elevation 6 m)

Mean Daily Temperatures (°C)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	8	8	12	17	21	24	28	30	26	20	15	11
MINIMUM	-1	0	2	7	12	17	21	22	18	12	5	0

Monthly Precipitation (liquid equivalent)

MEAN (mm)	48	74	107	135	147	165	142	152	234	208	97	56

3. Population and Culture. Japan's estimated total population is 126.55 million and is highly urbanized (78%). Average population density is 338.2 persons per sq km. However, nearly the entire population lives on approximately 15% of the country's land (the eastern coastal plains of northern Honshu, Tokai, Chugoku, Nobi and Konsai, and northeastern Kyushu), making this area one of the most densely populated in the world (1,930 persons per sq km). The population's ethnic make-up is 99.4% Japanese and 0.6% other (mostly Korean). Religious preferences are 84% Shinto and Buddhist, and 16% other (including 0.7% Christian). Japanese civilization dates back to its founding by Emperor Jimmu in 660 B.C., and the culture is very rich in traditional customs, practices, ceremonies and beliefs. The Japanese are major consumers of fish and tropical timber. Japanese citizens are highly educated (99% literate). Life expectancy at birth is 80.7 years.

4. Sanitation and Living Conditions. Japan's abundant water sources include rivers, streams, ground water, and reservoirs. Most areas receive treated water. Under normal conditions, municipal water treatment meets U.S. standards. Although the integrity of the distribution systems is good, earthquakes often cause disruption of water supplies. Contamination of surface water occurs frequently during floods and typhoons. As of 1995, the sewerage connection rate was 54%, varying from 97% in cities with populations over 1 million to 17% in municipalities

with less than 50,000. The conventional activated sludge process accounts for 60% of wastewater treatment, with oxidation ditches accounting for another 20%. In more rural areas, storm sewers or drainage ditches move sewage and rainwater. In 1994, 10% of the total treated wastewater was recycled in industry, agriculture, and landscaping. Incinerated wastewater solids (ash) are used as building materials and as soil stabilizers. Collection and removal of solid waste are performed by both private and government sectors. However, over 25% of Japan's 1,901 operating household waste landfills reportedly fail to meet Japanese standards for preventing ground water pollution. There are nearly 1,900 municipal waste incinerators and almost 3,600 privately owned industrial incinerators. Reportedly, 75% of household and industrial waste is incinerated and less than 10% is buried in landfills. Despite regulations to improve environmental conditions in Japan, water pollutants in lakes, reservoirs, coastal seas, and rivers in urban areas remain at high levels. Red tides have frequently occurred in marine waters around Japan, contaminating fish and shellfish.

E. MONGOLIA.

1. Geography. Mongolia's area is approximately 1.565 million sq km, slightly larger than Alaska, and can be divided into three geographic regions: (1) The mountainous region consists of three major mountain belts in the west and northwest. The highest and most extensive is the westernmost Altai Mountains, which include the highest point in Mongolia, Tavan Bogd Uul (4,374 m) near the Chinese border. This mountain range extends for more than 1,600 km from Mongolia's northwestern tip to the southeast. The Hangayn Naruu, or Khangai Mountains, with a peak elevation of 3,905 m, run northwest to southeast near the center of Mongolia. The Hentiyn Naruu, or Khentel Mountains, run northeast to southwest, north of Ulaanbaatar, with elevations between 1,980 and 2,440 m. (2) The intermountain basins, lying between and around Mongolia's mountain ranges, are approximately 518 to 1,000 m above sea level and are characterized by fertile soil and numerous lakes. This region includes the lowest point in the country, Hoh Nuur, at 518 m. (3) Eastern Mongolia consists of a vast semidesert and desert plains, usually between 610 and 700 m above sea level. In the northeast, the plain comprises hilly steppes interspersed with hundreds of extinct volcanoes. In the south, a rolling, oasis-dotted plain forms the northern fringe of the Gobi Desert, which is one of the driest and coldest deserts in the world. The Gobi supports almost no vegetation. Surface water is rare in the east but is more abundant in the mountainous north, where rivers are rough and cascade over rocky beds.

Mongolia is landlocked and borders Russia to the north and China to the west, south and east. The rugged mountainous areas make transportation and physical communications difficult in western and northern regions. Dust storms often occur in spring, and grassland fires are sometimes a threat to humans and domestic animals. Mongolia has traditionally had an economy based on semiarid agriculture and animal husbandry. It also has extensive oil and mineral deposits, including coal, copper, tungsten, phosphates, tin, nickel, zinc and gold, but these have not been extensively developed. The collapse of the former Soviet Union has caused

internal political difficulties, and the transition from a communist economy to free and open markets has been slow and painful. Mongolia has to import most of its machinery and equipment, fuel, food, chemicals, building materials, and industrial consumer goods. Land uses include: 1% arable, 80% permanent pasture, 9% forests and woodlands, and 10% other. Mongolia has over 1,900 km of railways, more than 49,000 km of roads (less than 1,700 km of these are paved), and 34 airports (8 with paved runways). Rapid urbanization promoted by the former Communist regime and inadequately regulated industrial growth have led to air pollution, overgrazing, deforestation, soil erosion, and desertification. The extreme desert environment, with wide daily and seasonal temperature ranges, poses serious threats to human health.

2. Climate. The climate of Mongolia is harsh, characterized by bitterly cold winters and great variations in daily summer temperatures. Winter usually lasts from October through April. Mean daily temperatures in January, the coldest month, fall to -40ºC in the north and -19ºC in the Gobi Desert. Heavy snowfall occurs mostly in the mountains, but extremely fierce blizzards occasionally sweep across the steppes. Summer, which lasts from May through September, produces mean daily temperatures during July, the warmest month, that reach 15ºC in the north and 23ºC in the south. Summer daily temperatures may fluctuate by 30ºC or more. Severe sand and dust storms sometimes occur without warning. Precipitation is scarce. Only 250 to 400 mm of annual precipitation falls in the north, and rainfall rarely exceeds 127 mm in the Gobi Desert. Periodic droughts occur throughout the country.

Ulaanbaatar (elevation 1,325 m)

Mean Daily Temperatures (ºC)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	-18	-12	-3	6	12	20	21	20	14	6	-5	-16
MINIMUM	-32	-29	-21	-8	-1	6	10	7	1	-7	-20	-28

Monthly Precipitation (liquid equivalent)

MEAN (mm)	0	0	3	5	10	28	70	51	23	5	5	3

3. Population and Culture. Mongolia is sparsely inhabited, with a total population of about 2.65 million. Population density varies from a high of 274 persons per sq km in the capital of Ulaanbaatar to a low of 0.25 persons per sq km in the southern Gobi. The country is rapidly becoming more urbanized, a process that was started by the former Communist regime. Currently, the population is about 55% urbanized and about 83% literate. Ulaanbaatar, which had slightly more than 500,000 inhabitants in 1994, will exceed 900,000 by the year 2001. Mongolia's ethnic make-up is about 90% Mongol, 4% Kazakh, and 6% other. The people are

predominantly Tibetan Buddhist; about 4% are Muslims. From 1924 to 1990, the ruling Communist government severely limited the practice of all religions. Chinese and Mongol customs and cultural traditions predominate. Life expectancy at birth is 67.3 years.

4. Sanitation and Living Conditions. Through much of Mongolia, supplies of water are limited. However, in central Mongolia, water sources are reliable and include surface sources, dug and bored wells, springs, and melting snow. About 90% of the country's urban population has access to water treatment and distribution services, but defects in the distribution system, including leaks, power outages, and intermittent and chronic water shortages, often result in contaminated water at the tap. Municipal treatment systems supply water only to wealthier inhabitants of larger urban areas. Most water distribution is through public standpipes, which are supplying larger numbers of people as urban areas continue to expand. Many rural inhabitants must travel long distances to get water. Municipal sewage treatment systems are found in most cities but are insufficient for the volume of waste or do not function properly. Most sewage is discharged untreated into surface waters. Sanitation is inadequate for the large slum areas surrounding cities. Although semipermanent pit latrines provide sewage disposal for urban dwellers of "ghers" (tent-like structures), most rural gher dwellers move too frequently to establish fixed disposal sites. As of 1995, most cities in Mongolia did not have effective waste management programs to collect and dispose of solid waste. Wastes accumulate outside city buildings, in storm ditches, or other locations. In Ulaanbaatar, there are three landfills only 10 km from the city's center. Widespread water contamination, ineffective sewage treatment, and indiscriminate sewage and waste disposal all contribute to the risk of food- and water-borne diseases. Urban pollution is Mongolia's most severe environmental health problem, potentially affecting over half the country's population. Untreated industrial discharges and domestic effluents contribute to locally severe contamination. The Selenge River basin supports a high population density and is polluted with organic material, heavy metals, petroleum, phenols, nitrogen, and phosphorous. Mining wastes are a significant source of pollution. Soils around power plants are contaminated by ash, oil, and wastewater. Urban air pollution is primarily due to industrial stack emissions, thermal power plants, wood-heated ghers, wind-blown dust, and vehicle emissions, and is heaviest from October through April, when atmospheric inversions trap pollutants near the ground. Land degradation occurs from erosion, desertification, wildfires, overgrazing, mining, and other industrial activities.

F. NORTH KOREA

1. Geography. North Korea's total land area is 120,410 sq km, slightly smaller than Mississippi. The terrain is mostly hills and mountains separated by deep, narrow valleys, with a wide coastal plain in the west and discontinuous coastal plains in the east. The country can be divided into three geographic regions: (1) The Kacma Plateau, covering much of the northeast, has a mean elevation of 1,000 m. (2) The heavily forested Hamgyong Mountains rim the eastern edge of the plateau, rising to about 2,500 m and extending to the Sea of Japan. This range

includes North Korea's highest peak, Mount Paektu San, at 2,744 m. (3) The Pyongyang and the Chacryong Plains extend inland from the southwest coast of the Sea of Japan and cover approximately 520 sq km. North Korea is bordered by China and Russia to the north, South Korea to the south, the Sea of Japan on the east, and the Yellow Sea on the west. Tidal variations along the west coast are extreme, with a difference of 10 m between high and low tide. Land uses include: 14% arable, 2% permanent crops, 61% forests and woodlands, and 23% other. The mountainous interior is isolated and sparsely populated. Due to decades of mismanagement under a Communist regime, North Korea relies heavily on international aid to feed its population, while it continues to spend money and resources to maintain an army of over 1 million, the fifth largest in the world. Its long-range missile development and research on nuclear and chemical weapons are major concerns for the international community. Recent political overtures, and direct meetings between the leaders of North and South Korea, have greatly raised hopes of a peaceful reunification of the two countries. Natural resources include coal, lead, tungsten, zinc, graphite, iron, copper, gold, and hydropower potential.

2. Climate. The cool temperate continental climate of North Korea resembles that of Manchuria, producing long, cold, dry winters and wet summers, with short transition periods between seasons. Winters (November through March) are much colder and longer than in South Korea, with mean daily minimum temperatures of about -4ºC, and mean daily maximum temperatures of about 2ºC. Daily wind chills commonly reach -31ºC. Summers (June through September) have mean daily maxima of about 26ºC and mean daily minima of about 19ºC. In the northern mountains, winters are bitterly cold and heavy snows may cover the ground for months. Daily summer extreme highs occasionally reach 37ºC, while extreme lows may drop to 0ºC. Summer is the monsoon season, and two-thirds of the total annual rainfall (annual average 1,000 mm) occur from July through August. Severe flooding frequently occurs and typhoons occasionally strike during the summer. North Korea lost much of its food harvest in 2000 due to a prolonged drought that is also expected to destroy much of the harvest in 2001. Millions in rural areas will depend on food aid from South North Korea or face famine.

Pyongyang (elevation 27 m)

Mean Daily Temperatures (ºC)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	-2	0	6	15	21	26	28	28	24	17	18	0
MINIMUM	-13	-10	-3	3	9	15	20	20	13	5	-1	-9

Monthly Precipitation (liquid equivalent)

MEAN (mm)	15	10	25	46	66	76	236	229	112	46	41	20

3. Population and Culture. North Korea's estimated total population of 21.69 million is unevenly distributed. About 61% of the population lives in urban areas concentrated along the coastal lowlands of the Yellow Sea, particularly near the capital city of Pyongyang, and in the coastal northwest region. Population density averages about 195 persons per sq km. North Korea is racially homogeneous, primarily of Korean descent, with a small Chinese community and a few ethnic Japanese. The population is traditionally Buddhist and Confucianist, with some Christians and some Chondogyo (religion of the Heavenly Way), though religious activities have been severely suppressed. There are some government-sponsored religious groups that give the illusion of religious freedom. The population is about 59% urbanized and 99% literate. Life expectancy at birth is 70.7 years.

4. Sanitation and Living Conditions. Water supplies from rivers, creeks, springs, and wells usually are plentiful, but seasonal shortages may occur. Water treatment and distribution systems exist in urban areas but are unreliable. Poor maintenance, malfunctions from power cutbacks, chlorine shortages, and flooding contribute to contaminated water supplies. In rural areas, untreated water is usually obtained from dug wells or easily accessible surface water sources. Piped sewage disposal is provided in some urban areas in addition to open, covered ditches that discharge raw sewage directly into streams or the sea. Reportedly, Pyongyang releases at least half of its raw sewage directly into the Taedong River. Rural inhabitants use outdoor privies for waste disposal, and night soil is commonly used as fertilizer. Reports from the mid-1990s indicate that waste disposal in Pyongyang has not been a serious problem due to the low quantities of waste produced. Communities outside Pyongyang are said to heap all biodegradable wastes in the centers of towns to be used for fertilizing farms. Grossly inadequate water and sewage treatment result in high risks of contracting water- or food-borne pathogens and parasites. Heavy industrial contamination of the Tumen, Yalu, Chongehong, Imjin, Songehon and Taedong Rivers has been reported. Sources of pollution include wastewater from mining companies, paper factories, steel mills, textile plants, refineries, and chemical works. Water from the Tumen River has been described as unsuitable for industrial purposes due to discharges from mines along the river. The concentration of industrial zones in Wonsan, Chongjin, and Nampo contributes to localized pollution. Pollution is reportedly "severe" off the coasts of Nampo (site of the country's largest metal refinery) and Wonsan because of untreated factory wastewater. Red tides appear off both coasts between April and October. Heavy industrial emissions produce high levels of air pollution in and around Chongjin Hacju, Hanihung, Sunchon, Wonsan, Munjin, Munchon, Nampo, Songnim, Sariwon, Haeju, and Pyongyang. Humans in North Korea face significant risks of acute or chronic poisoning by these chemical wastes, as well as respiratory problems from airborne chemicals or particulates. Chronic food shortages and declining standards of living in recent years could result in widespread outbreaks of arthropod-borne diseases as well as epidemics of infectious and parasitic diseases. Living conditions have become so desperate that over 300,000 people have fled North Korea by entering China across the northern border.

G. SOUTH KOREA

1. Geography. South Korea has a total land area of about 98,190 sq km, slightly larger than Indiana, and is 70% mountainous. It is bordered by North Korea to the north, the Sea of Japan on the east and south, and the Yellow Sea on the west. The Taebaek Mountains run in a north-south direction along the eastern coast. Peaks near the northern border remain snow-covered all year. From the Taebaeks, several other ranges extend in a northeast-southwest direction, though none exceeds 1,737 m elevation. There are wide coastal plains in the west and south. The highest point in South Korea is Jalla-san (1,950 m) on Cheju-do Island. More than 3,000 islands lie off the south and west coasts. Low-level seismic activity is common in the southwest. The river basins of the Han River in the northwest, the Naktong River in the southeast, and the Yongsan River in the southwest are heavily cultivated. The main crop is rice, which is harvested twice each year from wet paddies in the southern plains but only once in the northern dry plantations, where it matures at the end of summer. Land use comprises 19% arable, 2% permanent crops, 1% permanent pasture, 65% forests and woodlands, and 13% other. Natural resources include coal, tungsten, graphite, molybdenum, lead, and hydropower potential. South Korea has one of the most efficient and well-coordinated public transportation systems in the world. Trains and buses run punctually. The road, rail, and communications networks have been very well developed throughout the country. South Korea has more than 6,200 km of railroads, 86,900 km of roads (more than 70% paved), 103 airports (65% with paved runways), and at least 10 significant seaports. The nation's economy has been one of the strongest in Asia since the 1953 armistice that ended the Korean conflict. The labor force is employed mainly in services (68%), followed by mining and manufacturing (20%), and agriculture, fishing and forestry (12%). The main industries are electronics, automobile production, chemicals, shipbuilding, steel, textiles, clothing, footwear, and food processing.

2. Climate. South Korea's continental climate is hot and humid during summer, and cold and dry during the short winter. The countrywide average monthly temperature is -5°C in January and 26°C in August. While summer temperatures are relatively uniform throughout South Korea, winter temperatures are moderated by warm coastal waters; in Pusan, the average January temperature is 2°C. In Seoul, extreme temperatures occasionally reach 37°C in August and -24°C in December. About 70% of the annual rainfall is received during the summer monsoons (July through September). Most areas receive more than 1,016 mm of annual rainfall, with the Somjin River estuary in the southeast receiving more than 1,524 mm annually. Cheju-do island, located about 100 km south of the southwestern tip of the Korean peninsula, has a tropical climate. Occasionally, typhoons and seasonal storms bring high winds, heavy rainfall and rapidly rising, damaging floods.

Seoul (elevation 87 m)

Mean Daily Temperatures (ºC)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
MAXIMUM	0	3	8	17	22	27	29	31	26	19	11	3
MINIMUM	-9	-7	-2	5	11	16	21	22	15	7	0	-7

Monthly Precipitation (liquid equivalent)

MEAN (mm)	30	20	38	76	61	130	376	267	119	41	46	25

3. Population and Culture. South Korea's total population of 47.47 million is concentrated in major cities on the western and southern coastal plains. Average population density exceeds 461 persons per sq km, with Seoul containing more than 20% of the total population. South Korea is racially homogeneous. The population is primarily of Korean descent except for about 20,000 Chinese. Religious preferences are about 49% Christians, 47% Buddhists, 3% Confucianists, and 1% other (including Shamanists and Chondogyo - Religion of the Heavenly Way). The population is about 74% urbanized and 98% literate. Life expectancy at birth is 74.4 years.

4. Sanitation and Living Conditions. Primary drinking water sources include rivers (72%), reservoirs (19%), and groundwater. The Keum, Yongsan, Naktong, and Han Rivers are the main sources of water for irrigation and industrial use. Drinking water supplies are adequate, although occasional shortages occur in urban areas during summer. Municipal water is supplied to more than 84% of the country's population and to nearly 100% of the population in larger cities. However, most municipal water treatment and distribution systems are inadequate, leak, and are subject to contamination. The water system is plagued by obsolete equipment and insufficient storage capacity. Water-borne pathogens and parasites are common. South Korea's waste management practices are not yet equivalent to U.S. standards. The overall sewerage connection rate is 55% but varies by location. The rate is 95% in Seoul but only 35% in Cheju. Operational standards are higher for larger plants in metropolitan areas than for smaller plants. Many systems reportedly leak or drain effluent directly into rivers. Night soil "treatment" plants operate in some urban localities. Cities are responsible for the collection, transport, and treatment of municipal waste. Most waste is collected by the municipalities or by private waste operators. Municipal and nonhazardous industrial waste is disposed of in landfills, by recycling, or by incineration. In 1995, South Korea reportedly had 537 landfills and 3,800 incinerators (only 11 incinerators were large enough to treat 3,000 tons per day). Only 2% of landfills are equipped to prevent leachates from escaping and contaminating groundwater, and many incinerators do not meet emission standards required in the U.S.

An estimated 1.6 million tons of hazardous waste were generated in South Korea in 1995. Reportedly, most of this waste was subject to some level of treatment before disposal. About half underwent recycling. However, treatment is not keeping pace with the amount of waste being produced, causing storage and disposal problems. Hospitals are required to incinerate their own medical waste. According to the Organization for Economic Cooperation and Development, "the overall ambient water quality in Korea is subject to heavy pressures from municipal, industrial, and agricultural effluents." Most water sources receive high inputs of organic material, including untreated domestic waste water. The Han River and its tributaries reportedly receive about 15%, and the Naktong River receives 18% of South Korea's total industrial effluent volume, which includes volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), heavy metals, and petroleum wastes. Concentrations of total nitrogen and phosphorous increased dramatically in many rivers during the 1990s. The groundwater levels of nitrate are high in urban and agricultural areas, while trichloroethylene is found in groundwater in industrial areas. Agricultural chemicals are heavily used on farms and in rice fields. Marine waters are subject to pollution from land-based sources. Seriously polluted offshore waters include the areas near Kunsan, Pohang, and Pusan. Red tides occur seasonally each year in coastal bays, primarily along the Yellow Sea. Urban air concentrations of sulfur dioxide, nitrogen oxides, ozone, and particulate matter often exceed Korean and World Health Organization ambient air quality standards. However, annual average concentrations of sulfur dioxide in Seoul and other major cities have declined since the late 1980s. Particulate readings increase in the spring, when westerly winds deposit dust from mainland China.

H. TAIWAN

1. Geography. Taiwan, an island country about the size of Maryland and Delaware combined, has a total land area of approximately 32,260 sq km. It is located about 160 km east of the Chinese mainland and 480 km north of the Philippine island of Luzon. The island is bounded by the Taiwan Strait to the west, East China Sea on the north, Pacific Ocean on the east, and South China Sea on the south. The eastern two-thirds of the country consists of heavily forested mountains and hills that run north to south, including several peaks exceeding 3,000 m elevation. A densely populated coastal plain extends the length of the western one-third of the island. The highest point is Yu Shan (3,997 m) just southeast of the center of the island.

In 1949, following their defeat by the communists, 2 million Nationalist Chinese, under General Chiang Kai-Shek, fled to Taiwan and established a government that over five decades has gradually democratized and incorporated the native population. The island nation has prospered with its dynamic capitalist economy, but the main political issue continues to be the strained relationship between Taiwan and China and their eventual reunification. Taiwan lost its seat in the United Nations when the U.S. reestablished diplomatic relations with mainland (Communist) China in 1972. Since 1976 the U.S. has had no formal diplomatic relations with Taiwan. However, many key Taiwanese government and business officials maintain close ties with both

Japan and the U.S. Taiwan maintains unofficial commercial and cultural relations with the people of the U.S. through a private agency, the Taipei Economic and Cultural Representative Office (TECRO), with headquarters in Taipei and field offices in Washington, DC, and 12 other U.S. cities. Also, the American Institute in Taiwan (AIT), a private corporation, has its headquarters in Rosslyn, VA, and three offices in Taiwan. Traditional labor-intensive industries have been moved offshore and replaced by capital-intensive and technology-driven industries. A tight labor market has led to an influx of foreign workers, both legal and illegal. The labor force is employed in services (55%), industry (37%), and agriculture (8%). The people are relatively affluent and only 1% are considered to be living below the poverty line. Taiwan's main industries are electronics, petroleum refining, chemicals, textiles, iron and steel, machinery, cement, fishing, and food processing. Natural resources include small deposits of coal, natural gas, limestone, marble, and asbestos. Land use comprises 24% arable, 1% permanent crops, 5% permanent pasture, 55% forests and woodlands, and 15% other. The risk of earthquakes is high due to frequent seismic activity in the surrounding ocean floor.

2. Climate. Taiwan's climate, influenced by prevailing monsoon winds and surrounding seas, is tropical in the south and subtropical in the north. The temperatures are cooler at higher elevations in the central mountains. The southwest monsoons (July through August) bring rain to most of the country, while the northeast monsoons (October through March) bring rain only to the far north. Cloudiness is persistent and extensive year-round. Annual average rainfall for the island is 2,600 mm. Tropical cyclones occur from May through September but are most severe and frequent from July through September. Mean daily maximum temperatures vary from approximately 30°C during the warmer months (April through October) to 14°C during the cooler months (November through March). Relative humidity ranges from 75% to 95% throughout the year in most areas of the country. Frequent typhoons produce severe storms, strong winds, heavy rainfall, and devastating floods.

Taipei (elevation 9 m)

Mean Daily Temperatures (°C)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
MAXIMUM	18	18	21	25	28	31	33	32	31	27	23	20
MINIMUM	12	11	13	17	20	22	24	23	22	19	16	13

Monthly Precipitation (liquid equivalent)

MEAN (mm)	86	135	178	170	231	290	231	305	244	122	66	71

3. Population and Culture. Taiwan's estimated total population is 22.19 million. Its average population density of 571 persons per sq km is the world's second highest. The population density on the western plain reaches 985 persons per sq km. More than 1/3 of the population lives in the four large urban areas of Taipei, Kaohsiung, Taichung, and Tainan. Government efforts to relieve overcrowded cities by developing many small, intermediate cities are essentially urbanizing the entire island. The population's ethnic make-up is about 84% Taiwanese (including Hakka), 14% mainland (Han) Chinese, and 2% aborigines. Religious preferences include 93% who are a mixture of Buddhists, Confucianists and Taoists, 4.5% Christians, and 2.5% others. Modern Taiwanese culture and customs are an interesting mixture of traditional Han Chinese, native Taiwanese, and Western influences. The population is about 75% urbanized and 94% literate. Average life expectancy at birth is 76.4 years.

4. Sanitation and Living Conditions. The transformation of Taiwan from a rural agrarian society into a modern urban industrial country has radically changed the nature of its public health problems. Infectious and parasitic diseases have declined as cancer, heart disease and other chronic diseases of an aging population have increased. Taiwan's water sources include rivers, streams, canals, reservoirs, and groundwater. More than 80% of the population receives municipally treated and distributed water. However, Taiwan's water supply is deteriorating under the pressures of a rapidly growing population. Although treatment methods include coagulation, settling, filtration and chlorination, levels of industrial and agricultural chemical contamination exceed the capacity of most treatment systems. Contamination of surface water supplies occurs frequently after floods and cyclones.

Taiwan has a regulatory framework for the protection of its environment through laws enforced by the island's Environmental Protection Agency (EPA). Recently, Taiwan's EPA has begun to combat environmental pollution by imposing tighter regulations. Although municipal sewage treatment plants or septic systems serve most urban and rural areas, these systems are overloaded and more than 96% of household sewage is discharged untreated into streams, rivers and coastal waters. Indiscriminate defecation is common in rural areas. Night soil is still commonly used to fertilize crops. Consequently, food and water-borne pathogens and parasites remain significant public health problems. Municipal solid waste is collected for disposal through landfills, composting, or incineration. Taiwan has 6 operational incinerators, and 16 additional plants are planned. Half of the 290 operational landfill sites across the island are at capacity or will soon reach capacity; new ones are not being developed. Leaching from unlined landfills results in groundwater pollution from heavy metals and other toxic chemicals. Household wastes are not recycled.

Industrial waste is not regulated by the Taiwan EPA and roughly 73% of it is deposited in municipal landfills. The other 27% reportedly receives appropriate treatment, such as incineration, recycling, or other acceptable disposal methods. Significant quantities of fly ash produced from coal-fired energy plants and solid waste from incineration are deposited in

landfills. Taiwan's water sources are frequently contaminated by industrial, domestic and agricultural waste water. Studies on volatile organic compounds (VOCs) in drinking water detected high levels of trihalomethanes (THM) that exceed the U.S. EPA maximum acceptable contamination level of 0.1 mg/L. One study reported that the THM levels in Taiwan's municipally treated water are among the highest in the world, especially in tap water sampled in Kaohsiung and Taipei. Vehicle exhaust is the main source of air pollution in urban areas.

V. Militarily Important Vector-borne Diseases with Short Incubation Periods (<15 days)

A. Malaria.

Human malaria is caused by any of 4 protozoan species in the genus *Plasmodium* that are transmitted by the bite of an infective female *Anopheles* mosquito. Clinical symptoms of malaria vary with the species. The most serious malaria infection, falciparum malaria, can produce life-threatening complications, including renal and hepatic failure, cerebral involvement and coma. Case fatality rates among children and nonimmune adults exceed 10% when not treated. The other human malarias, vivax, malariae and ovale, are not life-threatening except in the very young, the very old, or persons in poor health. Illness is characterized by malaise, fever, shaking chills, headache and nausea. The periodicity of the fever, occurring daily, every other day, or every third day, is characteristic of the *Plasmodium* species. Nonfatal cases of malaria are extremely debilitating. Relapses of improperly treated malaria can occur years after the initial infection in all but falciparum malaria. *Plasmodium malariae* infections may persist for as long as 50 years, with recurrent febrile episodes. Persons who are partially immune or have been taking prophylactic drugs may show an atypical clinical picture. Treatment of malaria has been complicated by the spread of multiple drug-resistant strains of *P. falciparum* in many parts of the world. Current information on foci of drug resistance is published annually by the World Health Organization (WHO) and can also be obtained from the Malaria Section of the Centers for Disease Control and Prevention, and the Armed Forces Medical Intelligence Center.

Military Impact and Historical Perspective. Malaria has had an epic impact on civilizations and military operations. During the U.S. Civil War, 50% of the white troops and 80% of the black troops in the Union armies contracted malaria annually. During World War I, in the Macedonian campaign, the French army was crippled with 96,000 cases of malaria. In 1918, over 2 million man-days were lost in the British Macedonian Army because of malaria. During World War II, malaria caused five times as many U.S. casualties in the South Pacific as did enemy action. The highest annual incidence rate of malaria during World War II (98.5 cases per 1,000) occurred in the China-Burma-India theater. While malaria was a problem in certain parts of China, it was not as serious as it was in India and Burma. In 1942, malaria was the major cause of casualties in General Stilwell's forces in North Burma. There were 9,160 cases of malaria in the China-Burma-India theater during 1943, with nearly 115,000 man-days lost. At one time, 55% of the beds in the 20th General Hospital, located near Ledo in Assam, were occupied by patients with malaria. There were approximately 81,000 confirmed cases of malaria in the U.S. Army in the Mediterranean theater from1942 to1945. The average length of hospitalization for malaria in 1943 was 17 days, representing a total of 425,000 man-days lost during the year, or the equivalent of an entire division lost for a month. In 1952, during the Korean War, the 1st Marine Division suffered up to 40 cases per 1,000 marines. However, chloroquine became available throughout the entire Korean combat area by the late summer of 1950. Consequently, the incidence of malaria during the Korean War was low when compared

to the rates for World War II. Battle casualties accounted for only 17% of American hospitalizations during the Vietnam War. Many regiments were rendered ineffective due to the incidence of malaria, and many U.S. military units experienced up to 100 cases of malaria per 1,000 personnel per year. Elements of the 73rd Airborne Brigade had an incidence of 400 cases of malaria per 1,000 during 1967 and early 1968. Almost 300 military personnel contracted malaria during Operation Restore Hope in Somalia. Malaria remains a threat to military forces due to widespread drug resistance in plasmodia, insecticide resistance in the vectors, and the consequent resurgence of malaria in many areas of the world.

Disease Distribution. Endemic malaria has been eradicated from most temperate countries, but it still is a major health problem in many tropical and subtropical areas. Worldwide, there are an estimated 250 to 300 million cases of malaria annually, with 2 to 3 million deaths. The WHO estimates that in Africa nearly 1 million children under the age of 10 die from malaria every year. Globally, *P. falciparum* and *P. vivax* cause the vast majority of cases. *Plasmodium falciparum* occurs in most endemic areas of the world and is the predominant species in Africa. *Plasmodium vivax* is also common in most endemic areas except Africa. *Plasmodium ovale* occurs mainly in Africa, and *P. malariae* occurs at low levels in many parts of the world. In most endemic areas the greatest malaria risk is in rural locations, with little or no risk in cities. However, in Somalia during Operation Restore Hope (1993), several malaria cases occurred in troops who were only in Mogadishu.

The distribution of malaria in East Asia is depicted in Figure 1. There is no risk of malaria in Mongolia, Japan, Macau, Taiwan, or urban areas of Hong Kong, although malaria has been reported in the rural, northern border areas of Hong Kong. Extensive urbanization in Macau has resulted in the precipitous decline of most anopheline vectors. Importation of malaria by immigrant workers and by citizens of East Asian countries who have visited malaria-endemic areas is a constant threat. From 1968 to 1990, 936 cases of malaria were reported in Taiwan, where the disease was eradicated in 1965. Most were imported cases, but 86 cases of indigenous transmission resulted from these imported cases.

China: After the founding of the People's Republic of China in 1949, nationwide antimalarial campaigns were initiated by the central government. By the end of 1990, malaria had been nearly eliminated from many provinces of central China, and only 117,000 cases of malaria were reported countrywide. This was nearly a 99% reduction in cases from the 1950s. Henan Province once had the highest prevalence of malaria in China but reported only 318 cases in 1992. By 1998, only 31,300 cases were reported in China, and over 57% of these occurred in Hainan and Yunnan Provinces. The Chinese experience demonstrates that with community organization, exhaustive attention to case detection and treatment, plus the political will at all levels of society, it is possible to eliminate malaria from vast areas, even in a very large nation. Currently malaria transmission occurs only in rural areas in China below 1,500 m.

FIG. 1. DISTRIBUTION OF MALARIA IN EAST ASIA (DARK SHADING).

Some resurgence of malaria has occurred in southern provinces. *Plasmodium falciparum* occurs primarily if not exclusively in Hainan and Yunnan Provinces. Because of its international borders with Myanmar, Laos and Vietnam, Yunnan Province has a large number of imported cases of malaria, including a high proportion of *P. falciparum*. Mixed infections are common. Nearly 13,000 cases were reported from Yunnan Province in 1998, but the actual number was estimated to be 10 times as high, given the mobility of the population. This movement stems from Chinese workers coming from malaria-free provinces to work in the tropical lowlands, Chinese nationals working in neighboring countries, border trade, and refugees from Myanmar. Much of Yunnan is populated by ethnic minorities living in remote mountainous and forested areas that are difficult to reach.

There is a low risk of vivax malaria in the eastern provinces of Jiangsu, Shandong, Zhejiang, and Shanghai municipality, the central provinces of Anhui, Hubei, and Sichuan, and the southern provinces of Fujian, Guangdong, Guizhou, Hainan, Hunan, Jiangxi, and the Guangxi Autonomous Region. Sporadic cases of *P. malariae* are reported. Outbreaks of malaria still occur in the Three Gorges region of the Yangtze River. During and after the construction of the Three Gorges Dam project, breeding sites of *Anopheles* vectors will be extended to the irrigation network and low-lying flooded lands, and malaria prevalence may increase. There is no malaria in the northern provinces bordering Mongolia. Risk of transmission occurs in the western provinces only in the Ili valley of Xinjiang Autonomous Region, and only in the valley of the Zangbo River in southeastern Xizang (Tibet) Autonomous Region near the Indian and Burmese borders. North of latitude 33° N, transmission occurs from July to November; from latitude 33° N to 25° N, transmission occurs from May to December; south of latitude 25° N, transmission occurs year-round.

The presence of chloroquine-resistant falciparum malaria in Yunnan and Hainan Provinces was reported in 1974, and the disease has spread since then. Chloroquine resistance is currently present in Yunnan, Guizhou, Guangxi, and Guangdong Provinces, and especially Hainan Island. A chloroquine-resistant strain was also reported in Anhui Province as late as 1986. Multidrug-resistant falciparum malaria occurs in some areas of southern and southeastern China, especially Yunnan and Guangxi Provinces. The highest levels of drug resistance have been reported from the areas bordering Myanmar, Laos and Vietnam. In addition to chloroquine, resistance to amodiaquine, artemisinin (quinghaosu), mefloquine, piperaquine, quinine, and sulfadoxine/pyrimethamine (Fansidar™) has been reported.

Korea: After the Korean War, the National Malaria Eradication Service was implemented, and malaria rates declined. The Republic of Korea was declared malaria-free in 1979. However, malaria re-emerged in 1993 when an outbreak occurred in north Kyonggi-do and northwest Kangwon-do in and/or near the Demilitarized Zone (DMZ) bordering North Korea. Since the initial outbreak, several thousand cases of vivax malaria have occurred in South Korea. By the end of 1998, 6,249 cases had been reported, including 107 cases in US Army personnel. The

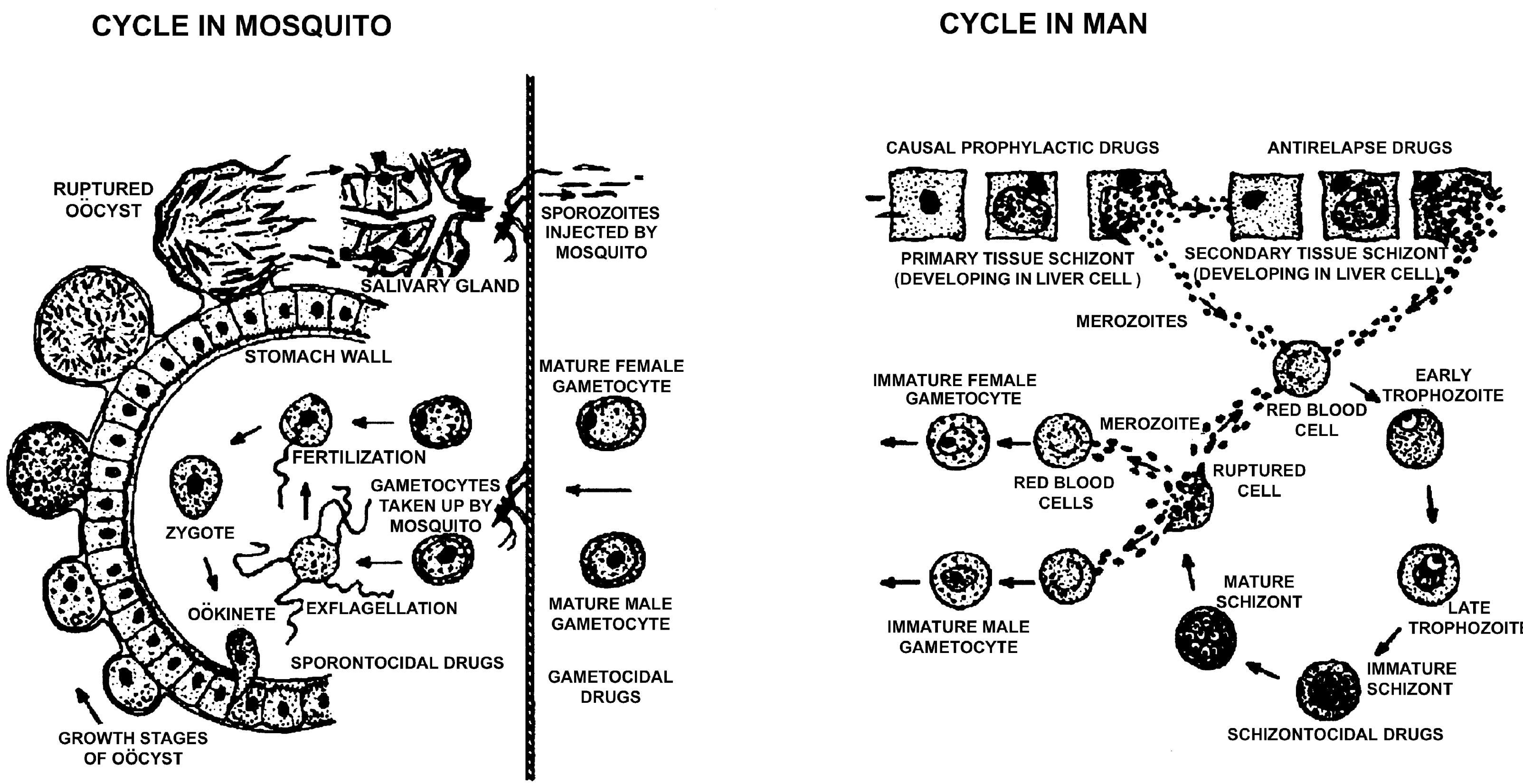
majority of cases (3,743; 61%) occurred in Korean soldiers camping in northwestern areas of South Korea. Among 2,399 civilian cases, 1,144 (47.7%) were Korean soldiers who had recently retired after military service in the DMZ. Although transmission of vivax malaria has occurred in southern provinces, this probably represents secondary transmission from retiring military personnel. Most civilian cases have occurred in people residing within 10 to 20 km of the DMZ or in individuals who had recently visited malarious areas during the transmission season. The origin of the outbreak has been attributed to infected *An. sinensis* mosquitoes that dispersed from North Korea, although the epidemiological factors responsible are unknown. Current risk of transmission is limited to the DMZ and rural areas in the northern parts of Kyonggi-do and Kangwon-do Provinces along the DMZ. Strains of *P. vivax* tested during this outbreak were chloroquine sensitive.

Transmission Cycle(s). Humans are the only reservoir host of human malaria. Nonhuman primates are naturally infected by many *Plasmodium* species that can infect humans, but natural transmission is rare. Female mosquitoes of the genus *Anopheles* are the exclusive vectors of human malaria. *Plasmodium* species undergo a complicated development in the mosquito. When a female *Anopheles* ingests blood containing the sexual stages (gametocytes) of the parasite, male and female gametes unite to form a motile ookinete that penetrates the mosquito's stomach wall and encysts on the outer surface of the midgut. Thousands of sporozoites are eventually released, and some of these migrate to the salivary glands. Infective sporozoites are subsequently injected into a human host when the mosquito takes a bloodmeal (Figure 2). The time between ingestion of gametocytes and liberation of sporozoites, ranging from 8 to 35 days, is dependent on the temperature and the species of *Plasmodium*. Malaria parasites develop in the mosquito vector most efficiently when ambient air temperatures are between 25°C and 30°C. Parasite development is prolonged during cool seasons and at high altitudes, and may exceed the life expectancy of the vector. Adult vector life span varies widely depending on species and environmental conditions. Longevity is an important characteristic of a good vector. Once infected, mosquitoes remain infective for life and generally transmit sporozoites at each subsequent feeding. Vector competence is frequently higher with indigenous strains of malaria. This may decrease the likelihood that imported strains from migrants will become established.

Vector Ecology Profiles.

General Bionomics. Female anopheline mosquitoes must ingest a bloodmeal for their eggs to develop. Feeding activity begins at dusk for many species, although many others feed only later at night or at dawn. Most anophelines feed on exposed legs, although some may feed on arms, ears or the neck. Infected females tend to feed intermittently and thus may bite several people. Eggs mature 3 to 4 days after the bloodmeal and are deposited one at a time, primarily in clean water with or without emergent vegetation, depending upon the mosquito species. A single female may deposit up to 300 eggs. Mosquito larvae feed on organic debris and minute organisms living in aquatic habitats. Oviposition sites include ground pools, stream pools, slow

FIGURE 2. LIFE CYCLE OF *PLASMODIUM,* THE MALARIA PARASITE



moving streams, animal footprints, artificial water vessels, and marshes. Deep water (over 1 m in depth) is generally unsuitable for larval development. There are 4 larval instars, and 1 to 2 weeks are usually required to reach the nonfeeding pupal stage. The pupa is active and remains in the water for several days to a week prior to adult emergence. The life span of females is usually only 1 to 3 weeks, although under ideal conditions female mosquitoes may live for 2 to 3 months. Longevity of individual species varies. A long life span is an important characteristic of a good vector. The older the anopheline population is in an endemic area, the greater the potential for transmission. Males live only a few days. Females mate within swarms of males, usually one female per swarm. Males and females feed on plant sugars and nectar to provide energy for flight and other activities.

Adult Feeding, Resting, and Flight Behavior. *Anopheles* spp. that are strongly attracted to humans are usually more important as vectors than those species that are strongly zoophilic. *Anopheles* generally fly only short distances from their breeding sites. The flight range is the distance traveled from the breeding site over the course of the mosquito's lifetime. This is important when determining how far from military cantonments or human settlements to conduct larviciding operations. Vectors that feed and rest indoors are more susceptible to control by residual insecticides.

Specific Bionomics. Worldwide, about 70 species of *Anopheles* transmit malaria to man but only about 40 are important vectors. Anopheline vectors of malaria occur throughout East Asia, although transmission occurs primarily below 33^0 N latitude. The primary vector species in northern China and the rice-growing regions of the plains is *An. sinensis. Anopheles messeae* also transmits *P. vivax* in northern China but reportedly only in the Yili Valley. Between 25^0 N and 33^0 N latitude, *An. sinensis* vectors *P. vivax*, while *Anopheles lesteri anthropophagus* transmits *P. vivax* and, to a lesser degree, *P. falciparum*. Both *An. lesteri anthropophagus* and *An. yatsushiroensis* occur in China, Korea, and Japan; however, *An. yatsushiroensis* is not considered an important vector species in these countries. South of 25^0 N latitude, the principal vector is *An. minimus,* which can transmit both *P. falciparum* and *P. vivax*. *Anopheles minimus* occurs widely in East Asia, from west-central to southeastern China (including Hong Kong) and Taiwan. It also occurs in Japan's Ryukyu Archipelago. *Anopheles dirus* is an important vector of both *P. falciparum* and *P. vivax* in China, but its distribution is limited primarily to Yunnan Province and Hainan Island. Secondary vectors in China include members of the *An. maculatus* group, *An. kunmingensis*, *An. jeyporiensis*, *An. sinensis*, and *An. philippinensis*. Among these species, with the exception of *An. kunmingensis*, *P. vivax* is the principal malaria species transmitted. *Anopheles kunmingensis* also occurs at altitudes above 1,600 m. In Korea, the primary vector of *P. vivax* is *An. sinensis*, which also occurs in Hong Kong and Macau.

Anopheles dirus is a primary vector in southern China and Hainan Island, where it occurs in low forests, jungles and mature orchards. *Anopheles dirus* is a complex of seven species, but limited information is available about the distribution of the sibling species in East Asia. However, *An.*

dirus species A is known to occur on Hainan Island, while *An. dirus* species D occurs in Yunnan Province along the borders with Laos and Myanmar. This species complex generally inhabits hilly areas below 1,000 m. Adults are highly anthropophilic and feed indoors and outdoors. They often rest indoors but may become exophilic under selection pressure from residual insecticide treatments. The *Anopheles dirus* complex primarily feeds from 2200 to 0300 hours and generally exhibits two population peaks per year, one after the start of the spring rains and a second after the fall rains. Larvae occur in clear, cool, shaded water, primarily in isolated stream pools, ground pools, animal hoof prints, tire ruts, large water jars, or wells. *Anopheles dirus* rarely travels more than 2 km from its breeding site to feed. This species overwinters in the adult stage.

Anopheles minimus is the most widely distributed primary malaria vector in East Asia. The *An. minimus* complex comprises three known sibling species, but only two, *An. minimus* A and *An. minimus* B, have been reported from China, and little is known about differences in the bionomics of these two species, both of which occur on Hainan Island. *Anopheles minimus* A is considered more anthropophilic than *An. minimus* B, which prefers feeding on cattle and is more exophilic. There is little information on the distribution of the individual members of this species complex throughout East Asia. *Anopheles minimus* usually occurs at altitudes below 1,600 m. Adults are endophilic and endophagic in houses and animal sheds, and the species is highly anthropophilic over most of its range. *Anopheles minimus* feeds primarily from 2200 to 0200 hours during the warm season (late May to August). In cooler periods (September to early November) it tends to feed earlier, from just after dark to 2000 or 2100 hours. Adults often rest indoors after feeding. Larvae occur in clear, slow-moving, partially shaded stream pools, and in clear water at the edges of swamps, irrigation ditches, rice fields, and borrow pits. In southern China (Yunnan, Guangxi Provinces), this species overwinters in the larval stage, while in northern areas it overwinters in the adult stage. *Anopheles minimus* rarely flies more than 1 km for a bloodmeal.

Anopheles lesteri anthropophagus, a member of the *An. hyrcanus* group, is a vector of both *P. vivax* and *P. falciparum* but is primarily a *P. falciparum* vector in the southern part of its range. In Guizhou and Sichuan Provinces, it is often the most common species indoors and is considered highly anthropophilic. High infection rates are common. Larvae occur in clean, shaded, freshwater ground pools, along edges of lakes, in stone quarries, or ponds. This species overwinters in the egg stage.

Anopheles jeyporiensis is a secondary malaria vector in Guangdong Province and other southern provinces of China. It also occurs in Taiwan, Hong Kong, and Macau. It occurs largely in the foothills, often with *An. minimus*. It is anthropophilic, but not as much as *An. minimus*. *Anopheles jeyporiensis* feeds inside houses beginning about 2 hours after dusk. This species feeds sporadically through the night, rather than exhibiting periods of peak feeding activity. It

rests outside after feeding. Larvae inhabit clear, standing water or slowly moving streams with grassy margins.

Anopheles kunmingensis, another member of the *An. hyrcanus* group, is an important vector of malaria north of latitude 24° N and at elevations above 1,600 m in China. Adult mosquitoes are frequently caught resting inside houses and have exceeded 80% of the house-collected *Anopheles* in some study areas. This species is highly anthropophilic and anthropophagic. Rice fields, ponds and ditches are its most important larval habitats.

Anopheles messeae occurs in a small area of northwestern China in Xinjiang Autonomous Region. It is a minor malaria vector in China. This species is generally zoophilic. Adults overwinter in shelters, cellars, lofts or outbuildings. Larvae occur along the shores of lakes or in river valleys with luxuriant vegetation. Adults inhabit upland areas but are rarely abundant. *Anopheles messeae* is a marginal malaria vector because of its zoophilic habits and the lack of suitable habitats in Xinjiang.

Anopheles philippinensis occurs in low-lying areas of southern China, primarily where there are swamps and sluggish rivers. It is a marginal vector in this region. This species is zoophilic and exophilic. River beds are important larval habitats during the pre-monsoon and post-monsoon season, when smaller river channels are cut off from the main river. Larvae also inhabit the edges of rice fields or vegetated streams and rivers.

Anopheles maculatus is the most important vector of *P. vivax* in the *An. maculatus* complex. There are six additional sibling species in this complex, but little is known about their distribution and vector status. In East Asia the species complex occurs in the forested foothills of Taiwan and southern China, especially in Guangxi, Guangdong, and Yunnan Provinces. Adults of *An. maculatus* have a long flight season and are absent only during the colder months of November to early March. Adults are generally zoophilic and are more attracted to cattle than to man. *Anopheles maculatus* is an exophilic species that occasionally feeds indoors. Feeding occurs in the first 2 to 3 hours after sunset. This species is often present in areas that have been planted with rubber or fruit trees. Larvae breed in springs, seepages, and small streams exposed to partial sunlight.

Anopheles sinensis, a member of the *An. hyrcanus* group, is the most widespread East Asian malaria vector, occurring in virtually all countries and areas where malaria is transmitted. However, it is generally considered to be a poor vector, since it is primarily zoophilic and exophilic. Its role as a vector is limited to areas where it is most numerous and where human density is also high. *Anopheles sinensis* breeds in rice fields and exhibits population peaks after flooding of the paddies in March and again in September to October. It is a major vector in rice-growing regions in the plains of China. Its biting activity increases through the evening, reaches

a peak at midnight, then decreases toward dawn. Larvae also occur in ditches, swamps and seepage areas of rice paddies. This species generally has a flight range of 1 km or less.

Anopheles yatsushiroensis occurs in northern China, Korea, and Japan and is also a member of the *An. hyrcanus* group. Larvae occur in stagnant pools with some vegetation, often in stream pools at the edges of slow-moving streams, in rice fields, or irrigation ditches. Adults primarily feed on domestic animals. It is not an important malaria vector.

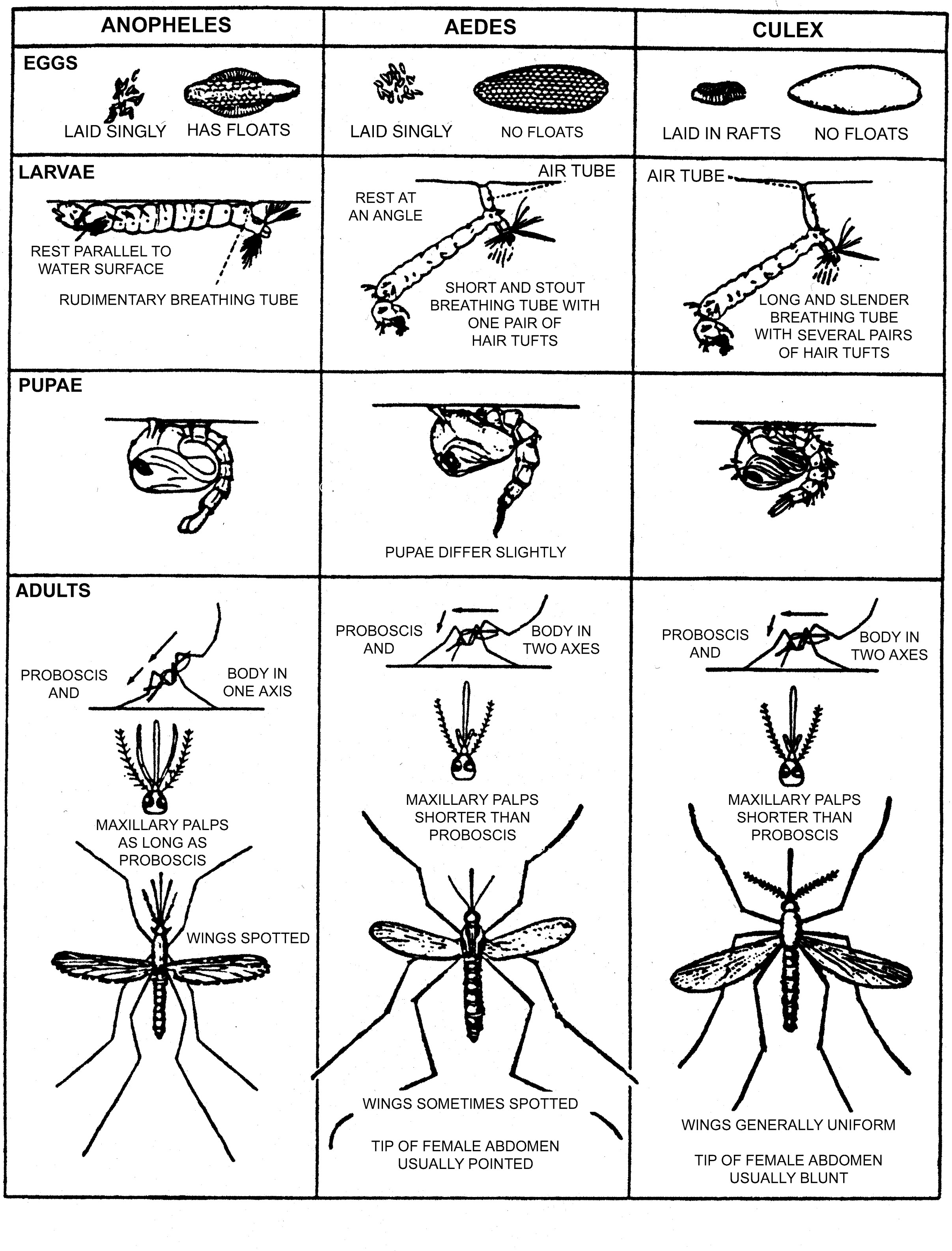
Vector Surveillance and Suppression. Light traps are used to collect night-biting mosquitoes, but not all *Anopheles* spp. are attracted to light. The addition of the attractant carbon dioxide to light traps increases the number of species collected. Traps baited with animals, or even humans, are useful for determining feeding preferences of mosquitoes collected. Adults are often collected from indoor and outdoor resting sites using a mechanical aspirator and flashlight. Systematic larval sampling with a long-handled white dipper provides information on species composition and population dynamics that can be used to plan control measures.

Anopheles mosquitoes have unique morphological and behavioral characteristics that distinguish them from all other genera of mosquitoes (Figure 3). Adult *Anopheles* feed on the host with the body nearly perpendicular to the skin. Other genera of mosquitoes feed with the body parallel or at a slight angle to the skin. These characteristics can easily be used by inexperienced personnel to determine if *Anopheles* are present in an area.

Eggs are laid singly and float on the water surface. They are dark, about 1 mm in length, and in most species are boat-shaped with a pair of lateral floats. The shape, size and pattern of the floats can be used to distinguish closely related species. *Anopheles* larvae hang with the body parallel to the water surface by means of specialized palmate hairs that are unique to the genus. *Anopheles* are also the only mosquitoes that lack an air siphon. *Anopheles* larvae feed on micro-organisms and small particles floating on the water surface. Entomologists have exploited this feeding behavior to control *Anopheles* larvae by dispersing insecticidal dusts that stay on the water surface. Larvae are easily disturbed by shadows or vibrations and respond by swimming quickly to the bottom. They may wait a few seconds or even minutes before they resurface. This behavior should be taken into consideration when surveying for mosquito larvae.

Malaria suppression includes elimination of gametocytes from the bloodstream of the human reservoir population, reduction of larval and adult *Anopheles* mosquito populations, use of **personal protective measures** such as skin repellents, permethrin-impregnated uniforms and bednets to prevent mosquito bites, and chemoprophylaxis to prevent infection. Specific recommendations for chemoprophylaxis depend on the spectrum of drug resistance in the area of deployment. Command enforcement of chemoprophylactic measures cannot be overemphasized. When Sir William Slim, British Field Marshal in Southeast Asia during World

FIGURE 3. *ANOPHELES, AEDES,* AND *CULEX* MOSQUITOES



War II, strictly enforced chemoprophylactic compliance by relieving inattentive officers, malaria attack rates declined dramatically. During the Vietnam War, malaria attack rates dropped rapidly in military personnel when urine tests were introduced to determine if chloroquine and primaquine were being taken.

Many prophylactic drugs, such as chloroquine, kill only the erythrocytic stages of malaria and are ineffective against the latent hepatic stage of *Plasmodium* that is responsible for relapses. Therefore, even soldiers who take chloroquine appropriately during deployment can become infected. Individuals who are noncompliant with the prescribed period of terminal prophylaxis are at risk for later relapses upon their return to the United States. During the Vietnam War, 70% of returning troops failed to complete their recommended terminal prophylaxis. The majority of cases in military personnel returning from Operation Restore Hope in Somalia resulted from failure to take proper terminal prophylaxis.

Application of residual insecticides to the interior walls of buildings and sleeping quarters is an effective method of interrupting malaria transmission when local vectors feed and rest indoors. Nightly dispersal of ultra low volume (ULV) aerosols can reduce exophilic mosquito populations. Larvicides and biological controls (e.g., larvivorous fish) can reduce populations of larvae at their aquatic breeding sites before adults emerge and disperse. Insecticides labeled for mosquito control are listed in TIM 24, Contingency Pest Management Guide. Chemical control may be difficult to achieve in some areas. After decades of malaria control, many vector populations are now resistant to insecticides (Appendix B, Pesticide Resistance in East Asia). Specially formulated larviciding oils can be used to control insecticide-resistant larvae. Pathogens, such as *Bacillus thuringiensis israelensis* and *B. sphaericus*, and insect growth regulators have also been used to control resistant larvae. However, there is growing evidence that resistance to these control agents has developed, although it is not nearly as widespread as resistance to chemical insecticides.

Sanitary improvements, such as filling and draining areas of impounded water to eliminate breeding habitats, should be undertaken to the extent possible. Rice needs considerable irrigation for high yields and this limits the possibilities for manipulating water to control mosquitoes. Well-designed drainage or flushing and careful timing of intermittent irrigation can control mosquito breeding but must be practical and economical to be accepted by farmers. Instead of draining, marshes can be excavated to form deep permanent impoundments with well-defined vertical banks that are unsuitable habitats for mosquito larvae. Other methods of source reduction can be utilized.

The proper use of repellents and other **personal protective measures** is thoroughly discussed in TIM 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance. The value of insect repellents is often forgotten by military personnel. Only a small proportion of U.S. soldiers (39 of 78 surveyed) used personal protective measures during

training in 1998 at a multipurpose range complex in Yongp'yong, Republic of Korea, even though local Korean residents were contracting malaria. The use of bednets impregnated with a synthetic pyrethroid, preferably permethrin, is an extremely effective method of protecting sleeping individuals from mosquito bites. In China the use of treated bednets has largely replaced the spraying of residual insecticides on the walls of houses to prevent transmission of malaria. Buildings and sleeping quarters should be screened to prevent entry of mosquitoes and other blood-sucking insects. The interior walls of tents and bunkers can be treated with permethrin to control resting vectors. See Appendix E for further information on **personal protective measures**.

B. Dengue Fever. (Breakbone fever, Dandy fever)
Dengue is an acute febrile disease characterized by sudden onset, fever for 3 to 5 days, intense headache, and muscle and joint pain. It is commonly called "breakbone fever" because of the severity of pain. There is virtually no mortality in classical dengue. Recovery is complete, but weakness and depression may last several weeks. Dengue is caused by a *Flavivirus* and includes 4 distinct serotypes (dengue 1, 2, 3 and 4). Recovery from infection with 1 serotype provides lifelong immunity from the same serotype but does not confer protection against other serotypes. Dengue hemorrhagic fever (DHF) and associated dengue shock syndrome (DSS) were first recognized during a 1954 epidemic in Bangkok, Thailand. DHF/DSS have spread throughout Southeast Asia, Indonesia and the southwest Pacific, Latin America and the Caribbean. DHF requires exposure to 2 serotypes, either sequentially or during a single epidemic involving more than one serotype. DHF is a severe disease that produces high mortality in children.

Military Impact and Historical Perspective. Dengue epidemics were reported in 1779 and 1780 in Asia, Africa and North America. For the next 150 years there were usually long intervals between major epidemics (20 to 40 years), mainly because the viruses and their mosquito vector were transported between population centers by sailing vessels. Dengue virus was first isolated and characterized in the 1940s. During World War II, the incidence of dengue was largely restricted to the Pacific and Asiatic theaters. Only scattered cases of dengue were reported from other theaters, including North Africa. Campaigns in the Pacific were marked by dengue epidemics, and throughout the war the U.S. Army experienced nearly 110,000 cases. At Espiritu Santo in the Pacific, an estimated 25% of U.S. military personnel became ill with dengue, causing a loss of 80,000 man-days. Although dengue was endemic in most of the China-Burma-India theater, the majority of cases among U.S. troops occurred in the vicinity of Calcutta, India. From 1942 to 1944, the incidence of dengue was 25 cases per 1,000 per annum. More recently, dengue was an important cause of febrile illness among U.S. troops during Operation Restore Hope in Somalia. A global pandemic of dengue began in Southeast Asia after World War II and has intensified during the last 15 years. Epidemics of dengue are noted for affecting large numbers of civilians or military forces operating in an endemic area. Outbreaks involving 500,000 to 2 million cases have occurred in many parts of the world.

Disease Distribution. Dengue is the most important mosquito-borne virus affecting humans and is present in nearly all tropical countries. Its distribution is congruent with that of its primary vector, *Aedes aegypti*, between 40° N and 40° S latitude. In recent years, dengue, especially DHF, has been expanding throughout the world. An estimated 2.5 billion people live in areas at risk for dengue transmission, and 30 to 50 million cases of dengue are reported annually. In East Asia, dengue outbreaks occur periodically only in Taiwan and China.

China: In 1978, dengue was reported in China for the first time in 32 years. Since then, epidemics involving hundreds of thousands of people have occurred in Guangdong and Guangxi Provinces and on Hainan Island. All four serotypes of dengue virus were isolated during these epidemics. *Aedes aegypti* was the vector in coastal areas, while *Ae. albopictus* was the vector in inland regions. Surveys demonstrated that *Ae. aegypti* bred mainly in domestic containers used for storing water, while *Ae. albopictus* bred not only in artificial containers but in rock caves, cement pools and tires. Evidence suggests that the re-emergence of dengue in China resulted from infected travelers and refugees from areas of Asia where dengue is endemic. The first epidemic of DHF/DSS occurred on Hainan Island during 1985 to 1986. The epidemic began in Zhan County in September, spread through the coastal areas, and ultimately involved 13 counties and cities of the island. The morbidity during this epidemic was 1,913 per 100,000, with a case fatality rate of 0.25%. All isolates were dengue 2 serotype. Currently, the risk of dengue transmission occurs primarily in southeastern China south of 42° N latitude and below 1,500 m. Most disease transmission occurs during the rainy summer months of June through August; in the tropical provinces, transmission extends from March through November. In 1999, dengue virus was isolated for the first time from patients and mosquitoes in Fujian Province.

Japan: The last and most widespread epidemic of dengue in Japan occurred in 1942 in the port city of Nagasaki. It soon spread to other cities and reoccurred every summer until 1944. Cases of dengue occurred during the 1950s in Okinawa. About 80 dengue cases were confirmed in Japan during the period 1985 to 1995. All were imported, with most cases acquired in Southeast Asia, primarily Thailand and the Philippines. Large numbers of Japanese visit dengue-endemic countries every year, and the number of imported cases diagnosed in Japan is probably under-reported. Five cases of dengue were reported during 1995-1996 in the Ryukyu Archipelago, including 4 cases of DHF. Dengue vectors are common in Japan, and endemic transmission could occur.

Dengue has historically been reported from Hong Kong, although no recent outbreaks have occurred. The risk of transmission is significant due to abundant vector populations and high rates of international travel and trade. Likewise, Macau has been free of dengue even though *Ae. albopictus* is one of the most abundant mosquitoes on the island. Dengue vectors are absent from western China (including Tibet and Xinjiang), all but a small area of southeastern Mongolia, and Manchuria. Dengue has not been reported recently on the Korean peninsula, although both *Ae. albopictus* and *Ae. aegypti* are present.

There have been a number of dengue epidemics over the last century in Taiwan. Following an island-wide epidemic in 1942, cases of dengue fever were not reported for nearly 40 years. In 1981, an outbreak of dengue 2 occurred in Liuchiu Hsiang, a small offshore island of Pingtung County. The estimated attack rate was 80%. A dengue outbreak occurred in the fall of 1987 in southern Taiwan involving 1,387 cases. The majority of cases were reported in Sanmin District of Kaohsiung City. Another epidemic took place the following year involving over 10,000 cases, including at least two cases of DHF. More than 60% of cases were reported from Kaohsiung Municipality. Growing affluence in Taiwan has led to increased travel to other countries. The risk of importing dengue from other endemic areas was illustrated by an outbreak in Kaohsiung City during 1991 that was initiated by a patient who contracted dengue fever during a trip to Thailand in May. The disease spread in the patient's community and even to other parts of Taiwan. A total of 175 cases were eventually confirmed. All 4 dengue serotypes were isolated during these epidemics. Fishing vessels that visit neighboring endemic areas may also introduce dengue virus into Taiwan. High levels of IgM dengue virus antibody have been found in the sera of people living near ports in southern Taiwan, indicating recent exposure to dengue virus. Current risk of transmission is highest in coastal areas where *Ae. aegypti* is considered the primary if not exclusive vector. Extensive larval surveys in Taiwan from 1988 to 1990 showed that *Ae. albopictus* is the dominant species and is widely distributed throughout the island below 1,500 m. *Aedes albopictus* occurs in highest densities in eastern Taiwan and in lowest densities in southern Taiwan, where competition with *Ae. aegypti* may occur. *Aedes aegypti* occurs mainly along the western coastal belt from south of Putai to north of Hengchun below 1,000 m. This species has gradually moved inland to Pingtung and the hilly region of San Ti Men. Dengue transmission occurs primarily in the warm rainy months from April through October, although transmission can occur throughout the year in southern Taiwan.

Transmission Cycle(s). Dengue virus is primarily associated with *Aedes* mosquitoes in the subgenus *Stegomyia*. The virus is maintained in a human-*Ae. aegypti* cycle in tropical urban areas. A monkey-mosquito cycle serves to maintain the virus in sylvatic situations in Southeast Asia and West Africa. However, dengue antibodies were absent from sera collected from 37 Japanese macaques (*Macaca fuscata*) in the early 1980s. Mosquitoes are able to transmit dengue virus 8 to 10 days after an infective bloodmeal and can transmit the virus for life. Dengue virus replicates rapidly in the mosquito at temperatures above 25°C. Evidence for transovarial transmission of dengue virus in *Ae. aegypti* has been demonstrated in the laboratory using dengue virus and *Ae. aegypti* strains collected from southern Taiwan.

Vector Ecology Profiles. *Aedes aegypti*, the primary vector of dengue, is widespread throughout East Asia. This species is more common in cities or in villages than in rural areas. It is very abundant in slums and shantytowns, where drinking water is stored in tanks or jars and there are numerous artificial containers. *Aedes aegypti* deposits its eggs singly or in small groups of 2 to 20 above the water line of its habitat. Eggs may withstand dessication for 3 months or more. Larvae emerge after eggs have been submerged for 4 or more hours. *Aedes*

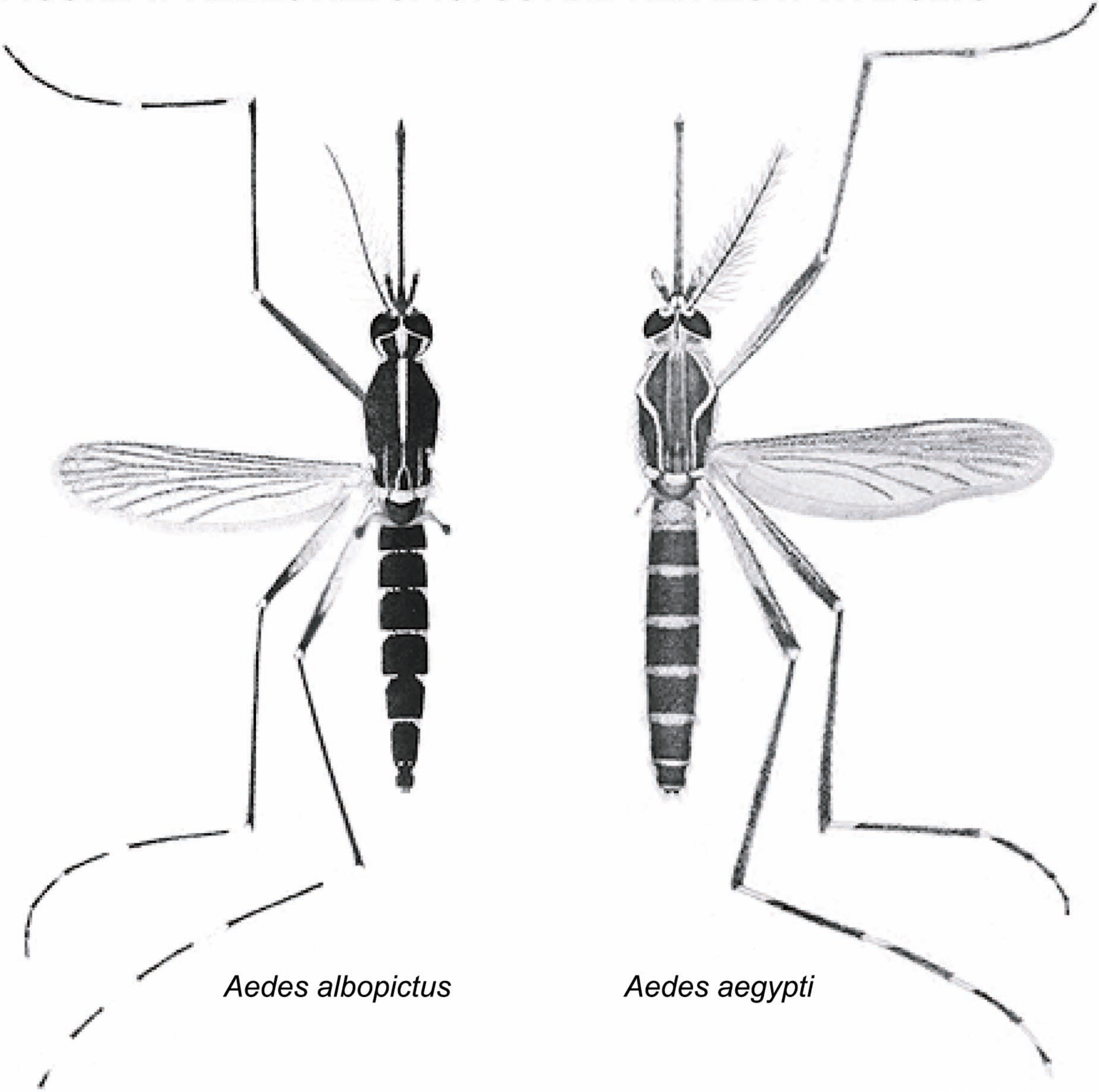
aegypti larvae live in artificial water containers, including flowerpots, cisterns, water jugs, tires, and flooded basements. The most common breeding sites during surveys taken since 1988 in Taiwan were ornamental containers (39%), water storage containers (30%), and discarded containers (25%). A study of the vertical distribution of dengue vectors in Kaohsiung City demonstrated that breeding occurred primarily in containers on the first 2 floors of multi-storied buildings. Larvae were not found breeding above the fourth floor. The abundance of larval populations usually parallels fluctuations in rainfall, especially during and after summer monsoons that occur in some parts of the region. Occasionally, *Ae. aegypti* is reported from coconut shells or bamboo stumps, although these are more typical habitats for *Ae. albopictus*. Larvae prefer relatively clean and clear water. They develop quickly in warm water, maturing to the pupal stage in about 9 days. Pupae remain active in the water container until adult emergence, 1 to 5 days after pupation. *Aedes aegypti* rarely disperses more than 50 m from its breeding site, but over several days it can disperse as far as 500 to 600 m. It does not fly when winds exceed 5 km per hour.

Aedes aegypti prefers human hosts and feeds primarily around human habitations. It is a diurnal feeder and readily enters homes. This species is not attracted to light; rather, it responds to contrasting light and dark areas presented by human dwellings. When feeding outdoors, it prefers shaded areas. It feeds on the lower legs and ankles, increasing its biting activity when temperatures and humidity are high. It is easily disturbed when feeding and, because it feeds during the day, is often interrupted by the movements of its host. This behavior results in multiple bloodmeals, often taken within the same dwelling, which increases transmission of the virus. *Aedes aegypti* rests in cool, shaded areas within dwellings, often in closets, under tables, or in sheds. Similarly, it rests outdoors in shaded areas among trees, shrubs, and structures.

Aedes albopictus is second only to *Ae. aegypti* in importance as a vector of dengue. Adults of the two species can easily be distinguished by the pattern of silver scales on the top of the thorax (Figure 4). *Aedes albopictus* is more common in rural than urban areas. Its larval and adult feeding habits are similar to those of *Ae. aegypti*, but it is more commonly found breeding in natural containers, such as tree holes, leaf axils, and fallen fruit husks. It is a slightly stronger flier than *Ae. aegypti*. *Aedes albopictus* is strongly anthropophilic but has a broader host range than *Ae. aegypti* and may feed on oxen, dogs and pigs. *Aedes albopictus* does not readily feed on birds.

Aedes albopictus most often occurs in rural, partially forested areas, particularly along forest fringes, where it may be present in large numbers. It is generally absent from the interiors of deep forests or jungles, although it is the dominant species of mosquito in bamboo forests of Taiwan and China. Eggs are deposited singly or in small numbers above the water line and hatch after being flooded for 1 to 7 days, depending on the state of embryo development. Eggs may withstand desiccation for several months if not flooded, and they are the

FIGURE 4. *AEDES ALBOPICTUS* AND *AE. AEGYPTI* ADULTS



overwintering stage in northern parts of East Asia. Larvae occur in manmade containers, bamboo stumps, coconut shells, tires, treeholes, and rock pools. Ceramic containers were preferred by *Ae. albopictus* over plastic or other manmade materials in surveys conducted in coastal areas of Chiayi County, Taiwan. Breeding sites are usually slightly shaded. *Aedes albopictus* is less likely to breed in indoor containers than *Ae. aegypti*. The larval development time varies from 5 days to 3 weeks, depending on temperature. Adults emerge 1 to 5 days after pupation. Females feed every 3 to 5 days for the duration of their life, which lasts from 1 to 4 weeks. Females fly close to the ground and generally not further than 100 m from their breeding sites. They do not fly in winds over several km per hour. Adults may also feed on nectar from plants. Autogeny occurs in this species, although usually only 2 to 4 eggs are produced in this manner. Peak feeding periods outdoors are generally early morning and late afternoon. Adults usually feed outdoors and rest outdoors in undergrowth. However, indoor feeding and resting behavior also occurs.

Experimental infection and transmission of dengue virus has been achieved with *Ae. flavopictus* in the laboratory, but this species was an inefficient vector. It should be considered a potential vector during dengue outbreaks in the absence of *Ae. aegypti* or *Ae. albopictus*. Dengue virus has occasionally been isolated from *Ae. riversi*, *Ae. dorsalis* and *Culex fatigans*, but these mosquitoes play no significant role in dengue epidemics.

Vector Surveillance and Suppression. Landing rate counts provide a quick relative index of adult abundance. The number of mosquitoes that land on an individual within a short period of time, usually 1 minute, is recorded. Resting collections entail a systematic search for dengue vectors in secluded places indoors, such as in closets and under furniture. Resting collection studies performed with mechanical aspirators are an efficient but labor-intensive means of evaluating adult densities. Densities are recorded either as the number of adult mosquitoes per house or the number of adult mosquitoes collected per unit of time.

Several indices have been devised to provide a relative measure of the larval populations of *Ae. aegypti*. The house index is the percentage of residences surveyed that have containers with larvae. The container index is the percentage of containers in each house that have larvae. The Breteau index is more widely used and is the number of positive containers per 100 premises. There is a risk of dengue transmission when the Breteau index goes above 5, and emergency vector control is indicated when the index exceeds 100. Adult egg-laying activity can be monitored using black oviposition traps that container-breeding *Aedes* readily utilize. The number of eggs laid in the ovitraps provides a relative indication of the abundance of dengue vectors. Ovitraps are especially useful for the early detection of new infestations in areas from which dengue vectors had been eliminated.

No vaccine and no specific treatment exists for dengue, so control of dengue fever is contingent upon reducing or eliminating vector populations. Ground or aerial applications of insecticidal

aerosols have been relied upon to reduce adult populations during epidemics of dengue. Many vector control specialists have questioned the efficacy of ULV adulticiding. In some outbreaks of dengue fever, ULV dispersal of insecticides has had only a modest impact on adult mosquito populations. *Aedes aegypti* is a domestic mosquito that frequently rests and feeds indoors and therefore is not readily exposed to aerosols. Lack of efficacy of adulticiding has necessitated a reevaluation of the strategies for the prevention and control of dengue. More reliance is now being placed on community-based integrated approaches to *Ae. aegypti* control, with greater emphasis on larval source reduction. In 1988 the Breteau index for the small island of Liuchiu was 54. After a community-based implementation of source reduction was undertaken, the Breteau index for *Ae. aegypti* declined to 1.2 by 1996.

Containers to store potable water were important breeding sources for *Ae. aegypti* during the dengue epidemics in southern Taiwan. The sides of large storage containers should be scrubbed to remove eggs when water levels are low. Water should be stored in containers with tight-fitting lids to prevent access by mosquitoes. A layer of oil will prevent mosquito eggs from hatching and will kill the larvae. The elimination of breeding sources, such as old tires, flowerpots, and other artificial containers, is the most effective way to reduce mosquito populations and prevent dengue outbreaks. Due to rapid urbanization and industrialization in recent years, the use of packing materials and tires has dramatically increased in Taiwan. By 1990, 3.5 million automobile tires and several million motorcycle tires were being discarded annually, providing important breeding sites for dengue vectors. An aggressive recycling campaign achieved an 80% recovery rate of used tires by 1993. Proper disposal of trash, bottles and cans at military cantonments must be rigidly enforced. The individual soldier can best prevent infection by using **personal protective measures** during the day when vector mosquitoes are active. Wear permethrin-impregnated BDUs and use extended-duration DEET repellent on exposed skin surfaces (see TIM 36).

C. Chikungunya Fever.
Disease produced by the chikungunya virus (*Alphavirus*, family Togaviridae) is characterized by sudden onset, fever, rash, nausea, vomiting, and severe joint pains that may persist as a recurrent arthralgia for months or even years. The incubation period is 3 to 11 days, and the acute illness lasts 3 to 5 days. Minor hemorrhages have been attributed to chikungunya virus disease in India and Southeast Asia. Convalescence is often prolonged. Recovery is usually complete followed by lifelong immunity. Inapparent infections are common, especially in children, among whom clinical disease is rare. Chikungunya can be differentiated from dengue in that pain is predominately located in the joints rather than the muscles, and the febrile period is shorter and usually not diphasic.

Military Impact and Historical Perspective. This disease was first recognized during epidemics that occurred in 1952 among inhabitants of Southern Province, Tanzania. Chikungunya is a Swahili word meaning “that which bends up” and refers to the stooping

posture adopted by patients because of the severity of the joint pains. The chikungunya virus was isolated in 1952, but its relationship to other arthropod-borne viruses was not fully determined until the late 1950s. Chikungunya viral infections are a significant military threat because of the lack of vaccines or specific therapy and the abrupt onset of this incapacitating infection. However, the threat appears to be minimal in East Asia, due to the limited prevalence of the virus in the region.

Disease Distribution. Chikungunya virus is enzootic throughout tropical Africa, from which it has spread to other parts of the world, primarily Southeast Asia and South Central Asia. Recent genetic studies indicate 2 distinct lineages of chikungunya virus. One contains all isolates from western Africa, and the second contains all southern and East African strains, as well as isolates from Asia. Serological surveys in China have usually detected seropositive rates in humans of less than 1%, although a serological survey conducted among a healthy population in Yunnan Province during 1986 found 7% positivity. Chikungunya virus has been isolated from bats in Zhan County, Hainan, and in Yunnan Province. Two isolates were also made from *Culex fatigans* in Hainan.

Transmission Cycle(s). There are no records of clinical disease in domestic animals or wildlife due to infection with chikungunya virus. However, there is strong evidence implicating wild primates as primary reservoir hosts. Antibodies to chikungunya virus have been found in the rhesus monkey, *Macaca mulatta*, which is widely distributed from the Indian subcontinent to northeastern China. Experimentally infected bonnet macaques, *M. radiata*, develop viremias sufficient to infect *Ae. aegypti.* This macaque is found in peninsular India. *Macaca cyclopis* is found in Taiwan and *M. fuscata* occurs in Japan. The role of these or other macaques in the epidemiology of chikungunya virus in East Asia is uncertain. In Asia most human outbreaks of chikungunya have occurred in urban areas, whereas in Africa human infections usually occur in rural areas. The virus can survive for considerable periods in the epidemic human-to-*Ae. aegypti* cycle, resulting in sporadic outbreaks at irregular intervals.

Vector Ecology Profiles. Most isolations of chikungunya virus in Asia have been made from *Ae. aegypti. Aedes albopictus* is an important secondary vector. Most experimentally infected *Culex* spp. and *Anopheles* spp. are refractory to infection with chikungunya virus. Transovarial transmission has been demonstrated in the laboratory in both *Ae. aegypti* and *Ae. albopictus*. However, transovarial transmission is generally considered insufficient to maintain the virus in nature, since chikungunya fever has disappeared from many urban areas where *Ae. aegypti* remains abundant. The biology of *Ae. aegypti* and *Ae. albopictus* are discussed in the vector ecology profiles section under dengue.

Vector Surveillance and Suppression. See this section under dengue.

D. Japanese Encephalitis.

Japanese encephalitis (JE) is caused by a *Flavivirus* in the family Flaviviridae and is closely related to St. Louis encephalitis virus. Many infections are inapparent or produce a mild systemic illness characterized by fever, headache or aseptic meningitis. Serological studies indicate a ratio of inapparent to apparent infections as high as 300 to 1. The incubation period is 5 to 15 days. Severe infections are marked by acute onset, high fever, extreme headache, and vomiting. Inflammation of the brain, spinal cord and meninges can cause stupor, tremors, convulsions (especially in infants), spastic paralysis, coma and death. Case fatality rates can be as high as 40%. Fatal cases result in coma and death within 10 days. Based on past epidemics, approximately 25% of clinical cases are rapidly fatal, 50% lead to permanent neurological or psychiatric sequelae, and 25% resolve within 1 to 2 weeks. Neurological impairment is most severe in infants. No specific therapy is effective and treatment is primarily supportive.

Military Impact and Historical Perspective. Although reports of a disease resembling JE go back to 1870 in Japan, the disease attracted little attention until a large epidemic in 1924 resulted in 6,125 cases and 3,797 deaths. JE was recognized in Korea in 1926 and in China in 1940. Japanese encephalitis virus (JEV) was first isolated in 1935 from the brain tissue of a fatal encephalitis case in Japan. No arthropod-borne virus causing encephalitis had been discovered, nor had the diseases that they cause been recognized prior to the 1930s. Consequently, there is nothing about JE or other arthropod-borne encephalitides in the medical history of World War I. During World War II, there was considerable preparation by U.S. military medical personnel for arthropod-borne viral encephalitides, but this group of diseases turned out to be less of a threat than anticipated. There was one small but important outbreak of Japanese encephalitis that involved both natives and troops on the island of Okinawa in the summer of 1945. Only 11 cases with two deaths were confirmed in U.S. military personnel. However, large numbers of U.S. troops had been assembled for the projected invasion of the home islands of Japan, and the danger of an epidemic was of great concern to medical personnel. The news of “a dread Japanese brain disease” on Okinawa had also spread among the troops, with demoralizing effects. The highest rate of incidence during the Korean War occurred in the opening months, reaching 28.3 cases per 1,000 in September of 1950. After November 1950, the incidence for any one month was not over 0.7 per 1,000. The commercial availability of effective vaccines against JE has greatly reduced the threat of this crippling disease to future military operations in JE-endemic areas. Only about 1 case of JE is reported per year in U.S. civilian or military personnel traveling or living in Asia.

Disease Distribution. JE is endemic in at least 21 countries from the maritime provinces of Russia, North Korea and Japan southward through China, Southeast Asia and Indonesia, and westward through the Indian Subcontinent. It is the leading cause of viral encephalitis in Asia, with 30,000 to 50,000 cases reported annually. Incidence has been declining in East Asia (Figure 5).

FIG. 5. DISTRIBUTION OF JAPANESE ENCEPHALITIS IN EAST ASIA (DARK SHADING).

China: JEV is enzootic countrywide except for Qinghai Province, and Xinjiang and Xizang Autonomous Regions. The highest risk of transmission occurs in central and eastern China, where rice fields and pig rearing coexist. Enzootics occur in the warm rainy months, usually May through September, but transmission may occur year-round in tropical southern provinces. There is low risk in urban areas. Consequently, JE does not occur in urban Macau or Hong Kong, although about a dozen cases have been reported in the last 10 years from rural areas of the New Territories.

Japan: The risk is highest in southeastern Japan and lowest in northern Hokkaido. Transmission occurs during the warm months with heavy rainfall, from March through November on Okinawa and other Ryukyu Islands, and June through September on the main islands of Japan. Incidence has declined among the local population as a result of extensive vaccination programs. Japanese farmers use smaller amounts of water and intermittent irrigation to raise varieties of rice that require shorter periods of cultivation. These modern agricultural techniques produce fewer mosquitoes. In addition, large-scale piggeries are located far from human habitations. Consequently, fewer than 50 cases of JE are reported annually. A total of 324 confirmed cases were reported between 1982 and 1996. An outbreak of JE occurred in 3 U.S. Marines training on Okinawa during 1991. These were the first cases of JE on Okinawa since 1974. Light trap collections on Okinawa from 1988 to 1993 indicated that populations of *Culex tritaeniorhynchus* and *Anopheles sinensis* might be declining.

Mongolia: JEV is not present.

North Korea: JEV is enzootic, but recent epidemiological data are not available. Current economic difficulties in the country may have reduced vaccination programs.

South Korea: JEV is enzootic throughout South Korea, although most recent cases have occurred in the southwestern portion of the Korean peninsula. The last major outbreak of JE occurred from 1982 to 1983. Sporadic cases are reported, most recently in 1994 and 1998. Transmission occurs primarily from June through October. There is little risk of acquiring JE in Seoul.

Taiwan: JEV is enzootic islandwide, but a national vaccination program since 1968 has decreased the incidence of JE to a few sporadic cases. Transmission occurs from April through October, with a peak usually in June. Human cases have been reported in and around Taipei and the Kaohsiung-Pingtung basins. An average of 25 cases of JE were reported from 1989 to 1991.

Transmission Cycle(s). JE is maintained in an essentially rural zoonotic cycle between ricefield breeding mosquitoes and water birds such as egrets, herons and ibises. Pigs are important reservoir hosts that develop high viremias and, when abundant, serve as the primary amplifying host for JEV. Mass rearing of pigs is very common in most countries of East Asia. Bovines

develop little or no viremia but do serve as a source of bloodmeals that help produce high vector populations of zoophilic mosquitoes like *An. sinensis*. Rodents and domestic animals are not important in natural cycles of JEV transmission, though almost all domestic animals can be infected. Adult animals rarely develop signs of illness, but fatal encephalitis does occur in horses. Several species of bats are susceptible to JEV and develop viremias for 6 days or more that are sufficient to infect mosquitoes. JEV has been isolated from bats in China and Taiwan. Human infections are usually a consequence of increased vector densities associated with increased rainfall or irrigation. How the virus overwinters in temperate climates and re-emerges in the spring to initiate enzootic cycles is not precisely known.

Vector Ecology Profiles.
Vector species occur in every country of the region except Mongolia, although their relative importance varies from country to country. In the Korean peninsula and Japan, the primary vector is *Cx. tritaeniorhynchus*, while the secondary vectors are *Cx. pseudovishnui*, *Cx. vishnui*, *Cx. gelidus* and possibly *Cx. pipiens pallens*. In Taiwan, at least five species are involved, including the primary vector *Cx. annulus*, and the secondary vectors *Cx. tritaeniorhynchus*, *Cx. pipiens quinquefasciatus*, *Cx. fuscocephala*, *An. sinensis*, and possibly *Ae. albopictus*. In China, the principal vector is *Cx. tritaeniorhynchus*, with secondary vectors including *Cx. pipiens pallens* and *Aedes albopictus*. A few rare isolates of JEV have been made from *Armigeres obturbans* and *An. hyrcanus*, but these species are probably insignificant vectors. Other vector species that occur in China are *Cx. vishnui* and *Cx. pseudovishnui*, although their relative importance is unclear.

Culex tritaeniorhynchus is the most important JE vector in most parts of East Asia. It occurs in huge numbers during the summer months of July and August, especially in rice growing areas, and feeds readily on such amplifying hosts as pigs and ardeid birds, as well as humans. It also is strongly attracted to cattle. This species is both endophagic and exophagic, but endophilic during the cool months in northern parts of the region. In warmer months, adults tend to feed outdoors. Adults begin feeding early in the evening, and continue feeding throughout the night, with decreasing activity after 0200 hours. They are moderately strong fliers that will travel an average of 3 km for a bloodmeal. However, laboratory studies using flight mills indicate that this species can fly as far as 20 km. *Culex tritaeniorhynchus* deposits egg rafts on the water surface that contain about 75 to 150 eggs each. They are deposited 3 to 4 days following a bloodmeal. Eggs hatch 2 to 4 days after deposition. Common oviposition sites include ricefields, water troughs, irrigation spillovers and ditches, and undisturbed ground pools. Ricefields are generally colonized soon after the planting of the paddy, resulting in one large synchronous generation of adults over the normal six weeks of planting activity. Larvae of *Cx. tritaeniorhynchus* generally prefer lightly shaded ground pools with low concentrations of organic matter and some emergent vegetation. Larval development requires 7 to 9 days at a temperature range of 25° to 30°C. At lower temperatures, larval stages may require 15 to 20 days. The pupal stage lasts about 2 days. Development generally ceases below 16°C. In mid-

latitudes, adults are not active and diapause from late November to early February. In the northernmost part of its range, the species may completely disappear during winter and have to be recolonized by mosquitoes migrating from mid-latitudes the following spring. In southern areas of China and Taiwan, peak abundance occurs as early as June, with a possible secondary peak in September or October. *Culex tritaeniorhynchus* overwinters as larvae or adults. Increasing irrigation and cultivation of rice in many areas of China have contributed to the spread and abundance of this species. Transovarial transmission of JEV has been demonstrated in this species.

Culex annulus occurs in large numbers in rice growing areas of Taiwan; populations usually peak from July to August. Small, secondary peaks occur in the pre-monsoon season from March to May and following the end of the monsoon in October. The life cycle of this species is very similar to that of *Cx. tritaeniorhynchus*, with a large synchronous generation emerging within 4 to 6 weeks after planting of the paddies. *Culex annulus* feeds primarily on swine, with 50% or more of its bloodmeals taken from this major amplifying host. Cattle, dogs, birds and man are also frequent hosts, in that order. In Taiwan, *Culex annulus* feeds predominantly within an hour after sunset, and nearly two-thirds of adults feed or rest in pig sheds where animal husbandry is widespread. In village areas, this species is more exophilic than in areas where there are pig sheds, but it will readily feed and rest indoors.

Culex vishnui and *Cx. pseudovishnui* occur widely throughout much of East Asia. Like *Cx. tritaeniorhynchus*, they breed primarily in rice paddies and shaded ground pools during warm, rainy periods from June through August. Both species are chiefly exophagic and exophilic, preferring to rest in fields or open forests, although a small percentage will feed on humans in houses. *Culex vishnui* feeds largely on pigs, while *Cx. pseudovishnui* is attracted to cattle. Birds are frequent hosts, especially for *Cx. pseudovishnui*. The life cycle is similar to that of *Cx. tritaeniorhynchus*, but the population peaks are generally much smaller. The flight ranges of these species are also similar to that of *Cx. tritaeniorhynchus*, averaging about 3 km from the breeding site to the furthest feeding sites. Transovarial transmission has been demonstrated in *Cx. pseudovishnui.*

Culex fuscocephala occurs in southeastern China and Taiwan. Its life cycle and seasonal abundance are similar to that of *Cx. tritaeniorhynchus*. Seasonal peaks occur from May through July or August, although there is often a second peak at the end of the monsoon season in October. Larval breeding sites include rice fields, borrow pits, and temporary ground pools with low organic content and some shade. This species is primarily exophagic but will feed in cattle sheds. It feeds continuously throughout the night except just before dawn, when feeding decreases greatly. *Culex fuscocephala* is largely zoophilic, preferring cattle to other hosts. However, it also feeds occasionally on pigs, dogs, and birds. It seldom feeds on humans. This species rarely disperses more than 2 km from its breeding sites.

Culex gelidus has been reported from Japan but probably occurs more widely in China and Taiwan. Adults feed on cattle, buffalo, goats, deer, pigs, chickens, wild birds, and often humans. Adults are attracted more to bovines than pigs. *Culex gelidus* is primarily zoophilic and exophilic but occasionally feeds and rests indoors. Larval breeding sites include ditches, ponds, borrow pits, temporary ground pools, and ricefields with clean water and some shade. The life cycle is similar to that of *Cx. tritaeniorhynchus,* although *Cx. gelidus* is far less abundant and only important as a secondary JEV vector.

Culex pipiens quinquefasciatus and *Cx. p. pallens* are common minor vector species in southern and northern parts of the region, respectively. *Culex p. quinquefasciatus* is particularly common in Taiwan. These species are both endophagic and exophagic, and somewhat endophilic during the cool months in northern parts of the region. Adults feed early in the evening, usually within 2 hours after sunset, and are strong fliers that will travel 3 to 5 km for a bloodmeal. The life cycle is very similar to that of *Cx. tritaeniorhynchus.* Preferred larval habitats frequently have a high organic content and include polluted ground pools, waste water seepages, and sewage lagoons. Population abundance of these species remains high during the entire warm, rainy season. They are primarily ornithophilic but also feed readily on dogs and, to a lesser degree, on pigs, cattle and humans. Adults become more endophilic in cooler weather. Both species are frequently observed resting in animal sheds and are strongly attracted to light. However, they are not as endophilic and endophagic as *Cx. annulus*.

Anopheles hyrcanus is a potential but insignificant JE vector. This is actually a species complex, and the sibling species can only be identified genetically. The complex is widespread throughout the region and can occur at high altitudes. This large, dark mosquito feeds on both humans and animals but prefers to feed on cattle outdoors. It may feed throughout the night and, occasionally, during the day in early morning hours or on overcast days. It occurs nearly year-round in southern parts of the region, but densities are generally low. The larvae breed in ricefields, swamps, grassy pools, borrow pits, and ditches. Adults are relatively strong fliers, traveling 3 to 5 km to feed.

The bionomics of *Ae. albopictus* is discussed in the section on dengue, and the biology of *An. sinensis* is discussed in the section on malaria. The life cycle of *Armigeres obturbans* will not be discussed, since it is an insignificant vector and is not abundant in most areas of the region.

Vector Surveillance and Suppression. Most *Culex* vectors of JEV are readily collected in light traps. Animal-baited traps can collect large numbers of zoophilic species. Adults can also be collected with an aspirator from animal sheds and other resting places. JEV can be detected in mosquitoes before outbreaks in humans occur. However, routine surveillance systems based on isolation of virus from mosquito pools are too time-consuming to be of practical use in most military situations. Testing sentinel pigs weekly for seroconversions has been used successfully by public health workers to detect JEV activity in many endemic areas. Implementation of

mosquito control is based on the occurrence of pig seroconversions, which generally precede JE outbreaks in the human population by 1 or 2 weeks.

Control of JE vectors with insecticides over large areas is impractical, environmentally unacceptable and prohibitively expensive. Application of insecticides to rice paddies may dramatically reduce larval populations, but they usually recover within 1 week. Some success in interrupting JEV transmission has been achieved by applying residual insecticides to the interior walls of houses, but studies in China have shown that this is not as effective as the use of bednets impregnated with a pyrethroid. Insecticide resistance has become widespread in many vector species (see Appendix B, Pesticide Resistance in East Asia). ULV aerosols may be useful in reducing adult populations during periods of epidemic JEV transmission. Long-term control is best achieved by environmental management of breeding sites, such as intermittent irrigation of rice paddies or the use of larvivorous fish. Protection of military personnel is best achieved by use of the **personal protective measures** outlined in TIM 36 and by vaccination. Vaccination programs in many East Asian countries have dramatically reduced the incidence of JE. Even though JE has declined in countries with vaccination programs, JEV remains highly enzootic in those countries. A large population of nonimmune individuals introduced into an enzootic area could experience high morbidity rates. In 1991, the hypersensitivity reaction rate among 14,249 U.S. Marines in Okinawa who received 36,850 doses of an investigational Japanese encephalitis vaccine was 10.3 per 10,000 doses.

E. Tick-borne Encephalitis (TBE).
TBE, caused by a complex of flaviviruses, actually comprises two clinically different diseases, Far Eastern TBE, also known as Russian spring-summer encephalitis (RSSE), and Central European TBE, also known as biphasic meningoencephalitis, or diphasic milk disease. Recent nucleotide and amino acid sequence analyses of European and Asian strains suggest that a third or Siberian subtype exists. Human disease of the Far Eastern subtype is usually clinically more severe in the acute phase and is associated with a higher rate of chronic nervous system sequelae than the Central European subtype. Far Eastern TBE has been a significant public health problem in central Russia since the 1930s. Case fatality rates have been as high as 40% in endemic areas. The case fatality rate for Central European TBE ranges from 1 to 5%. The term TBE is used to identify the broad spectrum of clinical syndromes caused by the virus, ranging from a simple febrile illness to severe central nervous system infection that may be fatal. However, about 80% of serologically documented infections are inapparent. The incubation period ranges from 7 to 14 days and is followed by fever, headache, muscle pain, nausea, vomiting and photophobia. In about 30% of patients the disease progresses to encephalitis, paralysis or even death. The highest mortality and most serious neurological sequelae occur in persons over 40.

Military Impact and Historical Perspective. Illness of the Far Eastern subtype was first described in 1937 during an epidemic in the Russian Far East. The Central European subtype

was clinically defined in 1948 during an epidemic in Central Bohemia. Although TBE virus exists in discrete foci, military personnel would experience a high level of exposure to vector ticks. TBE should be considered a serious threat to personnel deployed to East Asia due to the severe clinical nature of TBE viruses endemic to the region.

Disease Distribution. The tick-borne encephalitides occur along the southern part of the forest belt of temperate Eurasia, from the Atlantic to the Pacific Ocean. The Far Eastern subtype occurs in Siberia, the southern republics of the former Soviet Union, and northeastern China. The Central European subtype occurs in Europe, including Russia west of the Ural Mountains. The largest number of cases in recent years was observed in the Urals and in western Siberia. In the 1950s and 1960s, TBE was primarily an occupational disease contracted by forest workers and farmers in rural areas. During the 1970s and 1980s, up to 70% of reported cases were in urban dwellers that became infected during recreational outings in forests, usually within 3 to 8 km of towns. TBE is distributed throughout China and Japan. Cases of TBE have not been reported recently from Taiwan. The endemic status of TBE is unclear in North and South Korea, but cases have been reported historically on the Korean Peninsula, and competent tick vectors are abundant in many rural areas.

China: TBE, primarily of the Far Eastern type, is focally distributed throughout China in ecological conditions that are favorable to the primary vector, *Ixodes persulcatus*, and small rodent reservoirs of the virus. During the 1990s, natural foci of TBE were reported in the Hunchun area of Jilin, China, where antibodies against TBE virus were detected in 12% of the sera from wild mice and 11% of the human sera that were tested. Foci of RSSE were also found in 4 counties of the Tianshan Mountains, Xinjiang. *Ixodes persulcatus* was collected in 18 counties of the Tianshan Mountains, as well as the Alatau, Taerbahati and Altai Mountains. In 1989, 2 strains of RSSE virus were isolated from *I. ovatus* ticks collected at 2700 m in the subtropical region of western Yunnan, China, near the Burmese border.

Japan: TBE was first confirmed in Japan when the virus was isolated from an encephalitis patient in 1948. No further cases of TBE were identified in Japan until 1993, when a case was confirmed in a dairy farmer in Hokkaido, the northern large island of Japan. The virus was isolated from sentinel dogs, *I. ovatus* ticks, and rodents (*Apodemus speciosus* and *Clethrionomys rufocanus*) in 1995 and 1996 in Oshima, southern Hokkaido. These isolates were demonstrated to be closely related to RSSE virus.

Transmission Cycle(s). Humans acquire infection from bites of infected ticks or by crushing infected ticks on abraded skin. Infection can also be acquired by consuming raw milk or unpasteurized milk products, usually from goats. Because of this, military personnel should not consume local dairy products. Natural infections have been recorded in 16 species of ixodid ticks. *Ixodes persulcatus* is the primary vector in most endemic areas of East Asia and is also the primary reservoir of the virus. The virus overwinters in infected ticks and is passed

transstadially and transovarially. Important vertebrate hosts that amplify the virus are hedgehogs, shrews, field mice and voles. Besides small mammals, in natural TBE foci the most frequent hosts of immature ixodid ticks are birds, especially those species that spend large amounts of time searching for food or nesting on the ground. Avian hosts are not important as reservoirs of TBE virus, but migrating birds disperse vector ticks over long distances. There are reports of illness and death of dogs, calves, lambs, goats, wild birds and rodents after natural infection.

Vector Ecology Profiles.
The primary vector of this disease in most areas of East Asia is *Ixodes persulcatus*, although *Ixodes ovatus* is a potentially important vector. *Haemaphysalis concinna* is found extensively in Europe, northern Asia, and western Siberia and may be the principal RSSE virus vector in regions where it outnumbers *I. persulcatus*. *Dermacentor nuttalli*, *I. plumbeus*, and *I. crenulatus* are other possible vectors of this disease in the dry steppes of Mongolia, although these species rarely attack man. The life cycle of *D. nuttalli* is discussed in the section on boutonneuse fever, and the biology of *I. ovatus* is discussed in the Lyme disease section. *Ixodes plumbeus* and *I. crenulatus* are of minor importance and are not discussed further.

Ixodes persulcatus is generally distributed across the northern half of China from east to west, including Mongolia and Manchuria. It also occurs widely in rural areas of Korea and Japan, especially in the northern sections of these countries. It is a three-host tick. Larval and nymphal ticks parasitize small forest mammals (rodents and shrews) and birds, especially thrushes and warblers. In warm, dry periods, the larval ticks remain under ground litter where they contact burrowing animals. On cooler summer days, they move above ground where they find larger animals. Nymphal stages quest for their hosts several inches above the forest floor, often waiting on low-lying vegetation. Adults quest from 20 to 60 cm above the forest floor and usually feed on larger wild and domestic animals, such as rabbits, deer, bear, carnivores, dogs, goats and man.

The life cycle and seasonal distribution of *I. persulcatus* in China vary according to the different climates of the country. Adults generally attach on large animals from May to July. After feeding for 6 to 10 days, they detach, drop off the host, and lay 1,000 or more eggs. These eggs usually hatch in August and September. Eggs laid later in the fall may overwinter in that stage, while larvae that hatched and engorged earlier often overwinter as larvae. Eggs that hatch into larvae in the spring may produce nymphs during the same summer, and these will typically overwinter. Overwintering nymphs produce adults in the late spring that often lay eggs in August. Overwintering eggs hatch as larvae that are active in June. There are usually 2 peaks of larval activity, one in June and another in September. The entire life cycle requires at least 2 years but may take 3 to 4 years in colder regions. Like other ticks, this species is spread by migrating birds. Transstadial and transovarial passage of TBE virus occurs in *I. persulcatus*. The virus can survive at least 2 years in an infected tick.

Haemaphysalis concinna is a small tick that inhabits meadows alternating with clearings in birch-aspen timber, as well as sparse shrubs along rivers and streams, and marshy areas overgrown with sage or ferns. This species feeds on hares, hedgehogs, voles and other rodents in its immature stages. Adult females engorge for 3 to 9 days on cattle, sheep, goats and deer. They begin laying eggs 14 to 60 days after detaching from their hosts. Larvae emerge 30 to 60 days after oviposition, which usually occurs in June. Larvae engorge for 2 to 4 days, drop off the host and molt into nymphs 30 to 60 days after engorgement. Adults emerge from engorged nymphs 23 to 111 days after nymphs detach from their host. Larval and nymphal stages are more abundant in late summer and autumn. Nymphs that emerge late in the year may go into diapause and molt into adults the following spring. Consequently, adults occur more frequently from April through June, although adults can be collected through the summer and into October. In most cases the life cycle can be completed in one year, though development may require up to 3 years. Transstadial and transovarial transmission of TBE virus occurs, but not as efficiently as in other ixodid species.

Vector Surveillance and Suppression. Surveillance techniques for ixodid ticks are discussed in TIM 26, Tick-Borne Diseases: Vector Surveillance and Control, and under Lyme disease. Control of *I. persulcatus* and other tick vectors over large areas with acaricides is impractical and environmentally unacceptable. In areas where viral transmission is endemic, **personal protective measures** must be used. Regular inspection to remove ticks should be performed as often as practical.

A formalin-inactivated whole virus vaccine has been widely used in European countries for many years with few side effects. A full course of vaccination includes three primary doses, with a booster 6 to 12 months later. Vaccine efficacy approaches 97%; however, the FDA has not approved a vaccine for TBE. The vaccine could be administered to U.S. personnel only under an investigational new drug (IND) protocol. To protect U.S. military forces deployed to Bosnia in early 1996 as part of Operation Joint Endeavor, an inactivated, parenteral vaccine produced in Austria was offered on a volunteer basis to soldiers at high risk of exposure to TBE.

F. Ehrlichiosis. (Sennetsu fever)
Sennetsu fever, a form of ehrlichiosis, is characterized by sudden onset of fever, chills, headache, muscle and joint pain, sore throat, and swollen lymph glands. The etiological agent, *Ehrlichia sennetsu*, infects the mononuclear or polymorphonuclear leukocytes of the host. The course of the disease is usually benign, and fatal cases have not been reported. Human ehrlichiosis in the U.S. is a newly recognized disease, and the infectious agents are classified by the type of blood cell most commonly infected. There are two distinct forms of human ehrlichiosis: human monocytic ehrlichiosis (HME), caused by *E. chaffeensis*, that infects mononuclear phagocytes; and human granulocytic ehrlichiosis (HGE), caused by *Ehrlichia* spp. closely related to *E. phagocytophila*, *E. ewingii* and *E. equi*, that infects granulocytes. Symptoms are usually nonspecific. The most common complaints are fever, headache, and

nausea, and muscle and joint pain. Human deaths from ehrlichiosis have been reported in the U.S. In severe cases, serious central nervous system and cardiac involvement emphasize the potential gravity of infection with some species of *Ehrlichia* and our poor understanding of clinical manifestations. Disease caused by *Ehrlichia* spp. may be clinically confused with spotted fever but is distinguished by absence of a rash.

Military Impact and Historical Perspective. Until the 1980s, *Ehrlichia* spp. were classified as *Rickettsia* spp. and were known primarily as pathogens transmitted by ixodid ticks to dogs, cattle, sheep and goats. In 1953, the first ehrlichial pathogen of humans was identified in Japan. Interest in the study of ehrlichiae was stimulated by an epizootic of canine ehrlichiosis that resulted in 200 to 300 deaths among military dogs in Vietnam from 1968 to 1970. After the discovery in 1984 that the etiologic agent of Potomac horse fever was a novel ehrlichial species, designated as *E. risticii*, major advances were made in the knowledge of pathogenic *Ehrlichia*. The first well-substantiated report of a human infection with *Ehrlichia* in the U.S. appeared in 1986. Subsequently, 1,223 human cases of ehrlichiosis were reported in the U.S. through 1997. The first European case of acute HGE was confirmed in Slovenia in 1996; additional cases of human ehrlichiosis have been reported throughout Europe. Ehrlichiosis is an emerging tick-borne disease. At present, its military impact in East Asia would be minimal due to the limited distribution of sennetsu fever and the mild clinical disease caused by infection with *E. sennetsu*.

Disease Distribution. Most cases of sennetsu fever have been reported from western Japan. However, recent studies indicate that there may be natural foci of *E. chaffeensis* or a closely related species in southern China, where isolates have been made from *Amblyomma testudinarium* in Yunnan Province and *Haemaphysalis yeni* in Fujian Province. A granulocytic ehrlichia has also been isolated from *Ixodes persulcatus* collected in a forest area of Heilongjiang Province in northeastern China. At least 2 species (*E. canis* and *E. platys*) that cause canine ehrlichiosis are widely distributed in East Asia. A new species of *Ehrlichia*, *E. muris*, was isolated from the mouse *Eothenomys kageus*, collected in Aichi Prefecture in Japan in the early 1990s. This species has also been isolated from *Apodemus* mice and *Haemaphysalis flava* ticks. *Ehrlichia muris* has not been associated with human disease, although human antibodies to *E. muris* have been found in residents of metropolitan Tokyo. Strains of *Ehrlichia* closely related to *E. chaffeensis* have also been isolated from *Ixodes ovatus* in Japan. Their role in human disease is unknown.

Transmission cycle(s). The reservoir and vector of sennetsu fever are not known. Helminths have been suggested as primary vectors of the pathogen in fish. Patients with sennetsu fever often have a history of having visited rivers or swampy areas near rivers within 3 to 4 weeks of illness. In the U.S., *Amblyomm*a spp. and *Ixodes* spp. are the vectors of human ehrlichiosis. *Ixodes ricinus* has been implicated as the primary vector in Europe. Thus, the vector of sennetsu fever is probably a tick. Reservoir hosts in Europe are unknown but, based on studies in North America, wild rodents, deer and sheep probably play important roles in the epidemiology of

ehrlichiosis. Medical personnel should include ehrlichiosis in the differential diagnosis of febrile illnesses occurring after a tick bite. The potential for transmission of this pathogen through blood transfusions must also be considered.

Vector Ecology Profiles.
Primary vectors of human ehrlichiosis in East Asia have not been clearly identified.

Vector Surveillance and Suppression.
Tick avoidance and the proper use of repellents and other **personal protective measures** as discussed in TIM 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Importance, are the best means of preventing ehrlichiosis.

G. Crimean-Congo Hemorrhagic Fever.
Crimean-Congo Hemorrhagic Fever (CCHF) is a zoonotic disease caused by a tick-borne virus of the genus *Nairovirus*, family Bunyaviridae. The disease is characterized by febrile illness with headache, muscle pain and rash, frequently followed by a hemorrhagic state with hepatitis. The mortality rate can exceed 30%. The incubation period ranges from 3 to 10 days. CCHF may be clinically confused with other hemorrhagic infectious diseases. Humans are the only natural host of CCHF virus in which disease has been confirmed. The ratio of apparent to inapparent infections suggests that 1 of every 5 persons infected develops clinical illness.

Military Impact and Historical Perspective. Descriptions of a disease compatible with CCHF can be traced back to antiquity in eastern Europe and Asia. CCHF was first described in soldiers and peasants bitten by ticks of the genus *Hyalomma* while working and sleeping outdoors on the Crimean peninsula in 1944. The virus was first isolated in 1967. Since there are no available treatment regimens of proven value and recovery from CCHF can be protracted, military personnel with CCHF would require significant medical resources. There is limited evidence that ribavirin may be useful in the treatment of CCHF infections.

Disease Distribution. CCHF virus has the widest geographic distribution of any tick-borne virus. It is enzootic in the steppe, savanna, semi-desert and foothill environments of eastern and central Europe, Russia, parts of Asia, and throughout Africa. These are favored habitats of xerophilous *Hyalomma* ticks. Several Eurasian CCHF epidemics have taken a great toll of human life. In recent years, cases of CCHF have tended to be sporadic, with most reported from Bulgaria and South Africa. Bulgaria recorded 1,410 cases, primarily in agricultural workers, between 1953 and 1992. However, CCHF is underdiagnosed in many countries due to the lack of appropriate medical and laboratory services.

The only outbreaks reported from East Asia have occurred in the Xinjiang Autonomous Region in China. Since the first case in 1965, 260 cases had been reported up to the end of 1995. CCHF virus was isolated from sheep during a 1968 outbreak. Serosurveillance conducted since 1992

has found CCHF viral antibodies in up to 36% of villagers and farmers in the region. Based on these results, CCHF is also likely to be enzootic in western Mongolia.

Transmission Cycle(s). CCHF virus has been isolated from at least 30 species of ticks. From experimental evidence, it appears that many tick species are capable of transmitting the virus, but members of the genus *Hyalomma* are the most efficient vectors. The aggressive host-seeking behavior of adult hyalommine ticks makes them ideal vectors. The highest prevalence of antibodies in wild and domestic reservoirs has been found in areas where *Hyalomma* ticks are common. Domestic ruminants generally acquire infection early in life. Viremia in livestock is short-lived and of low intensity. Antibodies or virus have also been found in a variety of small mammals, including hedgehogs, hares, bats and rodents. Most birds are resistant to infection with CCHF virus. Infected wild and domestic animals show no serious signs of disease. Transovarial transmission of virus in vector ticks is an important reservoir mechanism. The wide range of tick species from which CCHF virus has been isolated, the diversity of life cycles and habitats of these ticks, and the uncertain involvement of various vertebrates have contributed to a poor understanding of the complex transmission and maintenance cycles of CCHF. Historically, the recognition of CCHF virus enzootic foci has been characterized by an unpredictable and sudden occurrence of human CCHF cases in presumably nonenzootic areas.

Persons occupationally exposed to domestic animals, such as animal husbandry and abattoir workers, are at greatest risk of infection. Humans acquire CCHF virus from tick bites, from contamination of broken skin or mucous membranes with crushed tissues or feces of infected ticks, or from contact with blood or other tissues of infected animals. CCHF virus is highly infectious, and nosocomial infection of medical workers has been important in many outbreaks.

CCHF virus loses infectivity shortly after the death of an infected host. There is no indication that consumption of meat processed according to normal health regulations constitutes a hazard.

Vector Ecology Profiles.
CCHF virus has been isolated from *Hyalomma asiaticum* in the Xinjiang Autonomous Region. This very large 3-host tick (engorged weights of 1.5 g have been recorded in females) is an inhabitant of deserts and steppes in the northern and western parts of China and Mongolia. Larvae and nymphs parasitize small rodents (such as gerbils), shrews, hares, hedgehogs and birds, while adults feed on cattle and wild ungulates. It is common for the larvae to remain attached and molt to the nymphal stage on the same host. After a bloodmeal, adult females may lay over 20,000 eggs in the spring that hatch from mid-June to mid-August. Larvae molt into nymphs by late summer or fall. Nymphs overwinter and molt into adults after a bloodmeal the following spring. Some nymphs may not find a host until late summer. Adults that emerge in the fall overwinter. The life cycle usually requires 2 years to complete.

Adult *H. asiaticum* may seek hosts as far as 500 m from where the nymphs have detached and molted, although they normally quest for hosts within 75 m of their place of detachment. This species is very tolerant of desiccation, but larvae and nymphs may remain in rodent burrows during hot summer days and seek a host only during the cooler early morning hours. *Hyalomma asiaticum* can survive loss of body water up to 50% before dying. During the cooler months, they seek hosts throughout the day. This species is also resistant to starvation and can survive over a year without a bloodmeal. Larvae feed for 7 to 8 days, while nymphs and adults feed about 9 days and 6 days, respectively. Both transstadial and transovarial transmission of CCHF virus occurs efficiently in *H. asiaticum.*

Vector Surveillance and Suppression. Military personnel should conscientiously use **personal protective measures** to prevent tick bites (see TIM 36). Frequent self-examination and removal of ticks are important. Ticks should be handled as little as possible and not crushed. Troops should not sleep, rest or work near rodent burrows, huts, abandoned rural homes, and livestock or livestock enclosures. Close contact with livestock and exposure to locally butchered animals should be avoided. Serological surveys of domestic animals are the most practical and economical surveillance systems for CCHF virus. Sheep, goats and cattle have exhibited high antibody prevalence to the virus in areas where human disease has been documented.

An inactivated mouse-brain vaccine against CCHF has been used in eastern Europe and the former Soviet Union on a small scale. The FDA has not approved a vaccine for human use. A purified modern vaccine will probably not be developed in view of the limited potential demand.

H. Boutonneuse Fever. (Mediterranean tick fever, Mediterranean spotted fever, Marseilles fever, African tick typhus, Kenya tick typhus, India tick typhus)
This tick-borne typhus is a mild to severe illness lasting a few days to 2 weeks. Clinical symptoms begin 6 to 10 days after the bite of an infected tick and include fever, headache and muscle pain. Boutonneuse fever is caused by *Rickettsia conorii* and closely related rickettsial organisms. Different strains of *R. conorii* isolated from ticks and humans indicate that this pathogen has substantial genetic and antigenic diversity. The common name of this disease comes from the button-like lesions, 2 to 5 mm in diameter, that develop at tick attachment sites. With antibiotic treatment, fever lasts no more than 2 days. The case fatality rate is usually very low, even without treatment.

Military Impact and Historical Perspective. Historically, boutonneuse fever has not significantly interfered with military operations. Sporadic cases among combat troops can be expected in limited geographic areas. The severity of illness is dependent upon the strain of *R. conorii* contracted. Because the spotted fevers are regional diseases involving different species or strains of *Rickettsia*, military medical personnel newly assigned to an area may be unfamiliar with them, and diagnosis may be delayed.

Disease Distribution. Boutonneuse fever is widespread in countries bordering the Mediterranean, and most countries of Africa. Along the European Mediterranean coast, the seroprevalence of boutonneuse fever in humans varies from 4.2 to 45.3%, depending on the area. Expansion of the European endemic zone to the north is occurring because North European tourists vacation along the Mediterranean with their dogs, which acquire infected ticks that are then brought home.

China: Early Chinese studies demonstrated that spotted fever group rickettsiae (SFG) were widely distributed across northern China from Heilongjiang Province to western Xinjiang Autonomous Region. In many surveys the serological methods used did not clearly distinguish the species of *Rickettsia* involved, but most studies indicated that they were more closely related to *R. sibirica* than *R. conorii*. Two recently isolated strains in the SFG were so distinct at the molecular level from previous strains that they were tentatively named *R. hulinii* and *R. heilongjiangii*. Recent serological evidence from humans and animals indicates that *R. conorii* is also enzootic in China. A 3-year study of SFG rickettsiae in Inner Mongolia revealed that nearly half the population tested had antibodies to *R. sibirica*. Infected persons, ticks and a high proportion of seropositive livestock and wild rodents were found in all 5 vegetative zones (desert, steppe, forest, forest-grassland, and grassland). Based on these results, *R. sibirica* is probably enzootic in Mongolia as well. The first confirmed case of spotted fever in Hong Kong was reported in 1992. Several additional cases caused by *R. sibirica* have subsequently been recorded.

Japan: SFG rickettsioses were not believed to exist in Japan until 3 clinical cases were reported in 1984 from Tokushima Prefecture, on the island of Shikoku in southwestern Japan. From 1984 to 1995, 144 cases of Japanese spotted fever (JSF) were reported by the National Institute of Health in Japan. These cases occurred along the coasts of southwestern and central Japan, where the climate is warm. The causative agent was isolated in 1986 and named *R. japonica*. JSF occurs from spring to autumn, while scrub typhus in the same areas usually occurs in the late autumn and winter. Seasonal occurrence may vary if JSF spreads to other parts of Japan.

Little is known about the epidemiology of SFG rickettsioses in Taiwan and the Korean Peninsula. Serological evidence has been demonstrated in rodents in Taiwan and humans in South Korea, but there are few reports of clinically confirmed cases.

Transmission cycle(s). The disease is maintained in nature by transovarial passage of rickettsiae in ticks, primarily the brown dog tick, *Rhipicephalus sanguineus*, in the case of *R. conorii*. Enzootic infection in dogs, rodents, hares and other animals is usually subclinical. *Apodemus agrarius*, *Microtus fortis*, *Clethrionomys rufocanus* and *Rattus tanezumi* are the principal rodents found infected in China. *Rickettsia sibirica* has also been isolated from hedgehogs and their ticks, *Dermacentor sinicus*, collected from numerous suburban localities of Beijing Municipality. *Apodemus speciosus* is the rodent most commonly infected with *R.*

japonica in Japan. A serosurvey during the mid 1990s in Shimane Prefecture found antibodies to *R. japonica* in 18.3% of street dogs, 17.9% of cattle, and 92.7% of wild deer tested. Dogs do not sustain infection for long but are significant because they bring ticks into close contact with people. Transmission to humans is by the bite of infected ticks. Contamination of breaks in the skin, mucous membranes, or eyes with crushed tissues or feces of infected ticks can also lead to infection. Close association with domestic dogs in endemic areas is a risk factor for boutonneuse fever.

Vector Ecology Profiles.
Almost any ixodid tick may harbor the pathogen, and many are important only as zoonotic vectors. In China, SFG rickettsiae have been isolated from *Dermacentor marginatus*, *D. nuttalli*, *D. niveus*, *D. silvarum*, *D. sinicus*, *Haemaphysalis concinna*, *Haemaphysalis japonicum*, *H. yeni*, *Hyalomma asiaticum* and *R. sanguineus*. In Japan, *R. japonica* has been isolated from *D. taiwanensis*, *H. flava*, *H. formosensis*, *H. hystricis*, *H. longicornis*, and *Ixodes ovatus*. Such a wide range of vectors may result from the existence of previously unrecognized species or serotypes that have been confused with *R. conorii* or other prototype species.

Rhipicephalus sanguineus, the brown dog tick, occurs throughout the entire region below 50° N latitude. This tick feeds primarily on dogs but also on camels, horses, sheep, gerbils and, occasionally, humans. It is a three-host tick, with larval and nymphal stages preferring to feed on rats or dogs, while adults feed primarily on dogs, and opportunistically on humans. Larvae and nymphs of *R. sanguineus* spend 3 to 6 days feeding on a host, then drop off to molt. Immature stages prefer long hair at the back of the neck, while adults are commonly found in the ears and between the toes of dogs. After mating on the host animal, the female feeds for 7 to 15 days, then drops off the host to lay eggs. Females lay hundreds of eggs, generally in the dens of host animals, usually canines, or in the cracks and crevices of infested houses. Eggs may require 10 to 20 days to hatch. Adult *R. sanguineus* are passive in their host-questing activity, rarely moving more than 2 m to find a host. This species requires a humid microhabitat, which it can often find in the dens of its hosts.

Haemaphysalis concinna occurs only in the northern latitudes of East Asia, including northeastern and extreme northwestern China, and the northern half of Mongolia. Its biology is briefly discussed in the section on tick-borne encephalitis. The biology of *Haemaphysalis longicornis* is reviewed in the section on Lyme disease.

Dermacentor silvarum inhabits taiga forests in northern areas of East Asia, a habitat dominated by spruce, pine and birch forests. This is a 3-host tick that feeds on rodents, hares, foxes and shrews as larvae and nymphs, while adults parasitize cattle, sheep, dogs, deer and, occasionally, humans. Adults can survive long periods without a bloodmeal, but immatures are not resistant to starvation. Adults may diapause over the winter with or without a bloodmeal, and female ticks frequently overwinter attached to the host. Transovarial transmission occurs in this species.

Dermacentor nuttalli is found primarily in northern and western provinces of China, including Xinjiang Autonomous Region and Inner Mongolia. It is a 3-host tick that inhabits grasslands along roadsides and forest edges and is rarely found in forests. Adults occur in decreasing numbers in May and may disappear by the end of the month. Immature stages feed on badgers, rabbits, ground squirrels, field mice and voles. Their populations peak in June and again in August. Adults feed on sheep, cattle and, occasionally, humans.

Vector Surveillance and Suppression. Personal protective measures (see TIM 36) afford the best protection against boutonneuse fever. In endemic areas, domestic dogs are commonly infested with the brown dog tick. Troops should not be allowed to feed, befriend or adopt local dogs as pets.

I. Q Fever. (Query fever)
This is an acute, self-limiting, febrile rickettsial disease caused by *Coxiella burnetii*. Onset may be sudden, with chills, headache and weakness. Pneumonia is the most serious complication. There is considerable variation in severity and duration of illness. Infection may be inapparent or present as a nonspecific fever of unknown origin. Acute Q fever is self-limited, and the case fatality rate in untreated acute cases is usually less than 1%. Chronic Q fever is a serious and often fatal illness with high mortality rates. Illness occurs months to years after the acute infection, and endocarditis occurs in up to 10% of patients.

Military Impact and Historical Perspective. *Coxiella burnetii* was originally described from Australia in 1937. In ensuing years, *C. burnetii* was found to have a worldwide distribution and a complex ecology and epidemiology. Q fever first appeared among Allied troops in 1944 and 1945, when several sharp outbreaks occurred in the Mediterranean theater. The disease was not recognized immediately because this rickettsial pathogen had been reported as occurring naturally in humans only in Queensland, Australia. The need to consider Q fever in the differential diagnosis of primary atypical pneumonia was recognized during this period, but it took several years for this knowledge to become widespread in field military medicine. The British Army in the Mediterranean experienced several localized epidemics of atypical pneumonia characterized by a high attack rate, up to 50% of some units. This was probably Q fever, but no serological proof was ever obtained. Three cases of Q fever were recorded in U.S. military personnel during the Persian Gulf War.

Disease Distribution. *Coxiella burnetii* has been reported from at least 51 countries. Incidence is greater than reported because of the mildness of many cases. Q fever is enzootic throughout East Asia, with most countries reporting sporadic isolated cases and occasional outbreaks. Antibodies to *C. burnetii* were detected in 50% and 40% of humans and sheep, respectively, in Ali Prefecture, Tibet, during a seroepidemiological study in the mid 1990s. Past studies indicate that Q fever is widespread in domestic animals in China, especially cattle and sheep. The emergence of Q fever has only recently been recognized in Taiwan, since the first confirmed

human case in 1992. Subsequently, most human cases have had a history of contact with domestic animals. Infection of cattle is widespread in Japan. In the early 1990s, up to 45% of some Japanese dairy cattle were seropositive for *C. burnetii*. Studies during the mid 1990s of school children in Shizuoka Prefecture suggest that *C. burnetii* may be a common cause of influenza-like symptoms in Japan. A 1994 study found that 48% of farmers and 40% of stock breeders were seropositive for Q fever rickettsia in some parts of South Korea. Based on these data, Q fever is likely to be highly enzootic in North Korea.

Transmission Cycle(s). In nature there are 2 cycles of infection with *C. burnetii*. One involves arthropods, especially ticks, and a variety of wild vertebrates. The most important reservoirs are small wild rodents, but infection has also been demonstrated in insectivores, lagomorphs, carnivores, ungulates, marsupials, monkeys, bats, birds, and even reptiles. During the early 1990s, 11 species of wild animals in 8 prefectures in Japan had antibodies to *C. burnetii*, including 78% of Japanese black bears (*Ursus thibetanus*), 69% of Hokkaido deer (*Cervus nippon yesoensis*), 63% of Japanese hares (*Lepus brachyurus*), 56% of Japanese deer (*C. n. centralis*) and 28% of Japanese monkeys (*Macaca fuscata*). Sixteen percent of the domestic cats tested from different areas of Japan had antibodies against *C. burnetii*, suggesting that cats may be an important source of human Q fever. High seroprevalences of *C. burnetii* antibodies have also been found in wild brown rat populations from 4 Oxfordshire farmsteads in Great Britain. This finding is the first report of *C. burnetii* among domestic rats outside India and suggests that commensal rodents may constitute an important reservoir for this pathogen. These results have not been confirmed in East Asia.

The other Q fever cycle is maintained among domestic animals. Although humans are rarely, if ever, infected by ticks, arthropods may transmit the infectious agent to domestic animals, especially sheep and cattle. A high percentage of cattle have antibodies to *C. burnetii* in Japan. Domestic animals have inapparent infections but shed large quantities of infectious organisms in their urine, milk, feces and, especially, their placental products. Because *C. burnetii* is highly resistant to desiccation, light and extremes of temperature, it can become aerosolized, causing widespread outbreaks in humans and other animals, often at great distances from the place of origin. Dust in sheep or cattle sheds may become heavily contaminated. Once established, animal-to-animal spread of *C. burnetii* is maintained primarily through airborne transmission. Airborne particles containing rickettsiae can be carried downwind for a mile or more. Outbreaks of Q fever in humans have been traced to consumption of infected dairy products and contact with contaminated wool or hides, infected straw, and infected animal feces. *Coxiella burnetii* may enter the skin through minor abrasions or mucous membranes. Although rare, human-to-human transmission of Q fever has occurred. Presence of the infectious agent in the blood and tissues of patients may pose a hazard to medical and laboratory workers.

Vector Ecology Profiles.
Several species of ixodid ticks transmit *C. burnetii* to animals but are not an important source of human infection. *Coxiella burnetii* has been isolated from *Haemaphysalis campanulata* in Sichuan and from *Hyalomma asiaticum* in Xinjiang. The role of these ticks in the epidemiology of Q fever in East Asia is unknown.

Vector Surveillance and Suppression. Although no commercial vaccine is available in the U.S., effective experimental vaccines have been developed. Severe local reactions occur in individuals with a positive skin or antibody test or a documented history of Q fever. Measures to identify and decontaminate infected areas and to vaccinate domestic animals are difficult, expensive and impractical. *Coxiella burnetii* is resistant to many disinfectants. Military personnel should avoid consumption of local dairy products and contact with domestic animals, hides or carcasses. Soldiers should not rest, sleep, or work in or near animal sheds or other areas where livestock have been housed.

J. Relapsing Fever (tick-borne). (Endemic relapsing fever, cave fever)
This is a systemic spirochetal disease characterized by periods of fever alternating with afebrile periods. The number of relapses varies from 1 to 10 or more. The severity of illness decreases with each relapse. The duration of tick-borne relapsing fever is usually longer than the closely related louse-borne relapsing fever. Mortality is seldom high, but morbidity may be severe. Illness is effectively treated with antibiotics. A number of species of *Borrelia* are responsible for this disease, but the taxonomy of these pathogens is complex. The close vector-spirochete relationship has led to the definition of most spirochete species by their tick vectors. There is great strain variation among tick-borne *Borrelia*, and a single strain can give rise to many serotypes. Some authorities have viewed all species as tick-adapted strains of the louse-borne relapsing fever spirochete, *B. recurrentis*, but molecular techniques are beginning to unravel taxonomic differences between strains.

Military Impact and Historical Perspective. Although clinical symptoms of tick-borne relapsing fever can be severe, impact on military personnel would be minimal due to the low incidence and focal nature of this disease in East Asia.

Disease Distribution. Worldwide, several hundred human cases are reported annually. The status of tick-borne relapsing fever is unclear in East Asia. The disease is endemic in east, central, and southern Africa, and throughout the Mediterranean region, extending eastward through Iran, Central Asia, and Kashmir (India) to western China. However, only sporadic cases have been reported in East Asia, and its current prevalence is unknown.

Transmission Cycle(s). Soft ticks of the genus *Ornithodoros* (family Argasidae) transmit tick-borne relapsing fever. Infection is transmitted from human to human, animal to animal, or animal to human by the bite of infective ticks. Rodents are sources of infection for ticks,

although ticks are more important as a long-term reservoir. In some tick species, the pathogen has been maintained naturally for years by transovarial transmission. The rate of transovarial transmission varies greatly among tick species. Ticks of both sexes and all active stages transmit the pathogen by bite or by infectious coxal fluids exuded from pores in the basal leg segments. Spirochetes can pass into bite wounds or penetrate unbroken skin. Exposure to infected blood of patients can cause infections in medical personnel.

Vector Ecology Profiles.
Ornithodoros spp. ticks are the vectors of tick-borne relapsing fever in East Asia. In addition to its role in the transmission of relapsing fever, this genus is important because it includes several species that inflict painful bites, some of which can produce local or systemic reactions in humans. Most *Ornithodoros* ticks inhabit restricted habitats, such as rock outcroppings, caves, dens, burrows, nests, and other sheltered habitats. Some species are parasitic on livestock and are found in stables, piggeries, animal pens and places where host animals rest. Adult *Ornithodoros* spp. feed at night, usually for only 1 to 2 hours. Males are slightly smaller than females but similar in appearance. Larvae may remain attached to their hosts for several days. Subsequent nymphal stages are active and require blood meals in order to develop. Engorgement is rapid, and nymphs drop off their hosts after feeding. Nymphs and adults of most species feed quickly and painlessly, so their bites may go undetected by the human host until well after the ticks have detached. After a variable number of molts (generally 4 to 5), adults emerge and mate. In contrast to ixodid (hard) ticks, female *Ornithodoros* do not die after oviposition. Females may live many years without a bloodmeal, but blood is required for egg development. Over the life span of the female, the number of eggs deposited may total several hundred, with up to 8 batches of eggs produced.

*Ornithodoro*s *tholozani* is the most important relapsing fever vector in East Asia, but its distribution is limited to the western Chinese provinces of Xinjiang and Qinghai. *Ornithodoros tholozani* tends to live in arid, sheltered areas, huts and stables. It feeds on camels, sheep and, less frequently, humans and birds. First instar larvae remain quiescent and do not feed, molting within a few hours. Subsequent nymphal and adult stages are active and feed on blood.

Vector Surveillance and Suppression. Argasid soft ticks like *Ornithodoros* are found in the restricted habitats of their hosts and rarely move very far. They occupy loose, dried soil of dwellings, cracks and crevices in mud-walled animal shelters, animal burrows and resting places, and the undersides of tree bark. They can be collected by passing soil through a metal sieve or by blowing a flushing agent into cracks and crevices and other hiding places. Some species are attracted by carbon dioxide, and dry ice can be used in the collection of burrow-dwelling ticks. *Ornithodoros* ticks also fluoresce under ultraviolet light. There is little seasonal fluctuation in numbers of argasids since their microhabitats are relatively stable.

Personal protective measures (see TIM 36) are the most important means of preventing bites and diseases transmitted by soft ticks. Tents and bedding can be treated with the repellent permethrin. Encampments should not be established in areas infested with *Ornithodoros* ticks. Troops should avoid using indigenous shelters, caves, or old bunkers, or areas frequented by domestic animals for bivouac sites or recreational purposes. Control of small mammals around cantonments can eliminate potential vector hosts. Rodent-proofing structures to prevent colonization by rodents and their ectoparasites is an important preventive measure. Limited area application of appropriate acaricides, especially in rodent burrows, can reduce soft tick populations. Medical personnel may elect to administer antibiotic chemoprophylaxis after exposure to tick bites when risk of acquiring infection is high. See Appendix E for **personal protective measures**.

K. Tularemia. (rabbit fever, deer fly fever, Ohara disease, Francis disease)
Tularemia is caused by the bacterium *Francisella tularensis* (formally *Pasteurella tularensis*). Two biovars with differing pathogenicity cause human disease. Jellison type A, or *F. tularensis* biovar *tularensis*, is more virulent and is restricted to North America. It can produce an untreated case-fatality rate of 5% to 15% due to pulmonary disease or from symptoms similar to typhoid. Jellison type B, or *F. tularensis* biovar *palaearctica*, is less virulent, and even without treatment produces few fatalities. It has been suggested that strains of *F. tularensis* biovar *tularensis* isolated in Japan are sufficiently different to be designated *F. tularensis* biovar *japonica*. Tularemia may be clinically confused with typhoid fever, plague and other infectious diseases.

Clinical manifestations vary according to the route of infection and the pathogenicity of the bacterial strain. Usually infection produces an ulcer or papule at the site of inoculation, with swelling of the regional lymph nodes. Abrupt onset of symptoms early in the course of illness includes fever, headache, abdominal pain, cough and vomiting. Ingestion of organisms in contaminated food or water may produce a painful pharyngitis, diarrhea and vomiting. Inhalation of infectious material may be followed by severe pulmonary disease. Tularemia is easily treated with antibiotics. Long-term immunity follows recovery, though reinfection has been reported.

Military Impact and Historical Perspective. The impact of tularemia on military operations would be minimal. Sporadic cases should be expected, but tularemia can be epidemic when water or food supplies are contaminated.

Disease Distribution. Outbreaks of tularemia have been reported from China, Japan and Mongolia. The best epidemiological data for tularemia comes from Japan. A total of 1,374 cases were reported in Japan between 1924 and 1996. About 94% of all cases were attributed to contact with diseased hares. Although tick-borne transmission is common in North America, it is infrequent in East Asia. Only 1.2% of the cases were arthropod-borne in the Japanese study.

However, arthropod-borne tularemia has increased since 1980. The disease occurs between May and October, when hikers are exposed to ticks and other blood-sucking arthropods. Most arthropod-borne cases have been reported from northeastern Honshu, the main island of Japan. Cases of tularemia have also been reported from numerous areas of Mongolia and China. In the mid 1980s, up to 14% of people tested in Tacheng District of Xinjiang Autonomous Region, China, had antibodies to *F. tularensis*. In the early 1990s, 2 % of people tested and 19% of sheep in Ali Prefecture, Tibet, were seropositive.

Transmission Cycles. The epidemiology of tularemia varies markedly in different geographic regions. *Francisella tularensis* has been isolated from over 100 kinds of wildlife and domestic animals and from the natural waters frequented by reservoirs such as the water vole, *Arvicola terrestris*, and muskrats. Infection among rodent species varies from asymptomatic disease to rapid death of an entire colony. The European brown hare, *Lepus europaeus*, is a very good indicator of the presence of tularemia in natural foci and has been used routinely in surveillance for this zoonosis in Europe. In Japan, where tularemia is called yato-byo or hare disease, *F. tularensis* has been isolated from the blue or mountain hare, *Lepus timidus*. *Lepus comus* is common in Yunnan and western Guizhou Provinces of China, while *L. sinensis* is found in eastern China. The Cape hare, *L. capensis*, inhabits northeastern and central China. *Lepus hainanus* is found on Hainan Island.

The primary mode of transmission in East Asia is by direct contact of the skin or conjunctivae with infected blood or tissues from hares and rodents. Other important routes of infection include the ingestion of contaminated food or water and the inhalation of infectious soil, grain, hay or other agricultural products contaminated with the excreta of infected animals. Rabbit meat frozen at -15°C has remained infective longer than 3 years.

Francisella tularensis has been isolated from at least 60 species of ticks, mites, fleas, deer flies and mosquitoes. Transovarial and transstadial transmission have been demonstrated in ixodid ticks. Other methods of acquiring the disease include direct inoculation into the skin from an infected animal bite or scratch. Under normal circumstances, person-to-person transmission does not occur, although congenital infection has been reported.

Vector Ecology Profiles.
Francisella tularensis has been isolated from *Ixodes ovatus*, *I. nipponensis*, and *Haemaphysalis flava* in Japan, *H. concinna* in Mongolia, and *Dermacentor niveus* and *D. marginatus* in China. All these ticks are known to parasitize humans, although there are probably other species involved in the zoonotic cycle of tularemia that also transmit the disease to humans in East Asia. The biology of these and other vector species is summarized in Appendix A.2.

Vector Surveillance and Suppression. Area vector control is not necessary. The permethrin-impregnated uniform is very effective against crawling arthropods such as ticks. Military

personnel should not handle rodents and should avoid rodent secretions. Wild rabbits and hares should not be hunted for food. Natural foci of tularemia appear to be stable and are unlikely to be eradicated. Live attenuated vaccines have been used extensively in the former Soviet Union and to a limited extent in the U.S. for occupational risk groups such as laboratory workers. Chemoprophylaxis is not recommended.

L. Scrub Typhus. (Tsutsugamushi disease, chigger-borne rickettsiosis, Japanese river fever, kedani fever, mite-borne typhus fever, tropical typhus)
Scrub typhus is a rickettsial disease characterized by a primary skin ulcer (eschar) that occurs at the site of attachment by an infected mite. The infectious agent is *Orientia* (formerly *Rickettsia*) *tsutsugamushi*. The incubation period is usually 10 to 14 days. Clinically, scrub typhus resembles other rickettsial diseases, with abrupt onset of fever, headache, malaise, and swollen lymph glands. Late in the first week of fever, a maculopapular rash appears on the trunk and extends to the extremities. Without antibiotic therapy, fever lasts about 2 weeks. The case-fatality rate in untreated cases varies from 6% to 35% but in some instances can be as high as 60%, depending on the area, strain of rickettsia, and previous exposure to the disease. *Orientia tsutsugamushi* strains exhibit great antigenic and genetic variation. Following an attack of scrub typhus, immunity to the homologous strain persists for at least 1 year. Mortality is highest among the elderly.

Historical Perspective and Military Significance. Descriptions of scrub typhus can be found in the Japanese literature as far back as 1810. The first English report of the disease appeared in 1878. Careful work during the 20 years before World War II established the basic epidemiology of the disease. Scrub typhus was second only to malaria as a cause of casualties in some Asiatic-Pacific military operations. On the Assam-Burma front, 18% of a single battalion was infected with scrub typhus in 2 months, and 5% of the total strength died from it. The total number of scrub typhus cases in U.S. Army forces in all areas from March 1942 through December 1945 was 6,717, and 967 of these occurred in the China-Burma-India theater. Detailed understanding of scrub typhus epidemiology, effective antibiotics to treat the disease, and highly effective clothing and skin repellents should make scrub typhus less of a threat to future military operations.

Disease Distribution. Scrub typhus is restricted to Asia and the western Pacific. Its range encompasses the maritime territories of Russia, Pakistan through India to Myanmar, Indonesia, Malaysia, Thailand, Southeast Asia, China, Taiwan, the Philippines, Japan, Papua New Guinea, northeast Australia and neighboring southwest Pacific islands south to about the Tropic of Capricorn. It occurs as high as 3,200 m above sea level in the Himalayan Mountains. The disease is associated with a wide range of habitats, including flooded river banks, dense forests in Southeast Asia disturbed by slash and burn cultivation, semi-deserts in Pakistan, and the alpine reaches of the Himalayas. The vector mite and the pathogen typically occur in fringe habitats where 2 vegetative zones meet, such as forest and scrub. Thus, a more appropriate name

for the disease is chigger-borne rickettsiosis. Scrub typhus has been reported recently from all countries in East Asia (Figure 6) except Mongolia. Based on Chinese data, scrub typhus is likely to be enzootic in Mongolia as well. There is little information about the number of human cases that currently occur.

China: Enzootic foci are known from Fujian, Guangdong, Guizhou, Hainan, Heilongjiang, Hunan, Jiangsu, Jilin, Liaoning, Shandong, Sichuan, Tianjin, and Zhejiang Provinces, and the Guangxi and Xizang Autonomous Regions. The highest risk exists in the temperate provinces of southeastern China. Transmission occurs year-round in southern provinces and from June through August in northern provinces with temperate climates. Sporadic cases have been reported from rural areas of Hong Kong. During the years 1979 to 1989, 59 cases were reported in British troops stationed in Hong Kong.

Japan: Scrub typhus is focally enzootic throughout Japan below 1,200 m. The number of cases gradually declined from 116 in 1950 to just 3 cases in 1969. Starting in 1976, there was a dramatic increase in the number of scrub typhus cases, which reached 941 in 1990. Highly endemic areas include Miyazaki and Kagoshima Prefectures in the southern part of Japan, Chiba and Kanagawa Prefectures near Tokyo, and Akita and Niigata Prefectures in the northern part of the country. Cases have occurred among U.S. military personnel training in the Mt. Fuji area. Transmission occurs from May through November.

Korea: Scrub typhus is enzootic in rural areas of North Korea, but current epidemiological data are not available. In South Korea, risk of transmission is highest along the southern coast and lowest along the eastern coast. Nearly 90% of cases occur from October through December, when vector populations are highest. Cases have been reported in U.S. military personnel stationed in South Korea.

Taiwan: Scrub typhus is focally enzootic countrywide and is one of the most commonly reported communicable diseases in Taiwan. It has been designated as a reportable disease since 1955. The highest incidence has been reported from Hualien and Taitung Counties and the Pescadores Islands. Kinmen, Matsu and the Orchid Islands are also highly endemic. Cases have occurred up to 2,000 m in Taiwan.

Transmission Cycles. Transmission is by the bite of an infected mite of the genus *Leptotrombidium*, subgenus *Leptotrombidium*. Hosts include a variety of small mammals and birds, but the most important reservoir hosts are wild rats in the genus *Rattus*. Domestic rodents are usually not involved in the epidemiology of scrub typhus. Many small mammals may serve as larval hosts, including shrews, mice and voles. *Apodemus speciosus* and *Microtus* spp. are important hosts in Japan. Only the larval stage of the mite can acquire and transmit infection,

FIG. 6. DISTRIBUTION OF SCRUB TYPHUS IN EAST ASIA (DARK SHADING).

since only larvae are parasitic. *Apodemus agrarius* is a common host in South Korea. The host range of a chigger species can be quite broad. In Taiwan, *L. deliense* has been collected from many small mammals, including *Rattus losea*, *R. tanezumi*, *R. rattus*, *R. norvegicus*, *R. coxinga*, *R. culcuratus*, *Bandicota nemorivaga*, *A. agrarius*, *A. semotus*, *Mus musculus*, *M. formosanus*, *Microtis kikuchii*, *Suncus murinus* and *Anourosorex squamipes*. Transstadial and transovarial passage of rickettsiae occur, and mites are considered the main reservoir of infection. Filial infection rates approach 100% in some studies. Experimentally, it has been difficult to infect *Leptotrombidium* mites by feeding them on infected rodents, and those chiggers that become infected rarely pass the infection transovarially to offspring. Most foci of scrub typhus are the result of natural or manmade changes in the environment and are characterized by the presence of vector mites, wild rodents, particularly *Rattus* spp., and transitional secondary vegetation such as grass, shrubs and saplings. *Leptotrombidium pallidum* is common in the parks and gardens of residential suburbs in Japan.

Vector Ecology Profiles.

The primary vector species in the region are *L. scutellare*, *L. pallidum*, *L. deliense* and *L. akamushi*. *Leptotrombidium scutellare* occurs in Japan south of Fukuoka Prefecture, the foothills of Mt. Fuji, the southern half of South Korea, and the southern and eastern parts of China north to Manchuria. *Leptotrombidium pallidum* is widely distributed in Japan, including Hokkaido, and throughout North and South Korea. *Leptotrombidium deliense* is widely distributed in southern and eastern China; it also occurs in the Amami Islands of Japan, as well as eastern Taiwan and the Pescadores Islands off Taiwan's west coast. *Leptotrombidium akamushi* is a principal vector in Akita, Aomori, Niigata, and Yamagata Prefectures of Japan, in Fujian and Guangdong Provinces of China, and in some parts of Taiwan. At least 82 species of *Leptotrombidium* have been recorded from China, and surveys have indicated that there may be many other species of chiggers acting as vectors in East Asia. *Leptotrombidium kawamurai* is a suspected vector that occurs widely on many Japanese islands, from Hokkaido in the north to Okinawa in the south, but has a limited distribution on the Japanese mainland. *Orientia tsutsugamushi* has been isolated from *L. fuji* in Japan, from *L. orientale*, *L. palpale*, and *L. zetum* in South Korea, and from *L. gaohuensis*, *L. insularae*, *L. kaohuense*, *L. inhuaikonense*, *L. palpale*, *L. rubellum*, and *Walchia pacifica* in China.

Incidence of scrub typhus occurs during the time of peak abundance of the vector. Seasonal prevalence studies in South Korea revealed that *L. pallidum* appeared in September, peaked in November, almost disappeared during December through March, reappeared in April and May, then almost disappeared again until September. Also in South Korea, *Leptotrombidium scutellare* peaked during October, sharply declined thereafter, and then disappeared during January to September. In Kagoshima Prefecture, Japan, *L. scutellare* was present from October through February, with a sharp peak in October and November. *Leptotrombidium pallidum* occurred from August to May, with a broad population peak from October through March.

Chigger vectors inhabit submontane, tropical, and temperate zones in East Asia. Hilly areas with disturbed vegetation are the primary habitats, and in many areas the life cycle continues year-round. Adult mites lay 1 to 5 eggs per day in damp, well-drained soil. Over a period of 6 to 12 weeks, 300 to 400 eggs may be deposited. The six-legged larvae that emerge ascend the tips of grasses to heights of 6 to 8 cm to await a suitable host. Most often, hosts are rodents, birds or insectivores, although humans are readily attacked. The distribution of the mites is dependent on the home ranges of the hosts, which do not usually overlap. Mite colonies therefore tend to be isolated from each other and occur as "mite islands." Their focal distribution is also due to their specialized ecological requirements. Relatively small changes in the moisture content of the soil, temperature and humidity can affect the survival and distribution of chigger mites. Larvae attach themselves to host tissues with mouthparts known as chelicerae and form a stylostome (combination of chigger mouthparts and host tissues, also called a feeding tube) at the point of attachment. Larvae are very small (0.15 to 0.3 mm), but after engorging they may increase sixfold in size. They are usually reddish or orange but may also be pale yellow or straw-colored. On rodents or birds, primary attachment sites for larval chiggers are inside the ears or around the eyes. They may also congregate around the anus and genitalia. On people, the trunk and extremities are the primary attachment sites. Chiggers seek out areas where clothing is tight against the skin, such as the waist or ankles. A lesion or eschar usually develops at the feeding site of each infected chigger.

Chiggers do not suck blood. The feeding tube allows tissues digested by the chigger's saliva to be pumped into the digestive tract. This may require several days, although some chiggers will feed and drop off the host within 48 hours. Larvae that have fed develop into inactive, eight-legged protonymphs. Protonymphs molt to the active deutonymph stage. The next stage, the tritonymph, is also inactive and molts to the adult stage. Both the deutonymph and adult stages are free-living predators of soil-inhabiting arthropods and their eggs. Adults are small mites (1 to 2 mm), usually reddish and covered with numerous feathered hairs, giving them a velvety appearance. The nymph resembles the adult but is smaller (0.5 to 1.0 mm), and the body is less densely covered with hairs. The life cycle may occur in as little as 40 days in tropical areas, resulting in several generations per year. In more temperate areas of China, Japan and Korea, up to 300 or more days may be required to complete the life cycle. During cold months of the year, adults enter partial or complete diapause.

Vector Surveillance and Suppression. Larval chiggers can be collected directly from hosts. Attached chiggers can be removed from dead or anesthetized animals with fine forceps and placed for temporary storage in 70% alcohol. Alternatively, a dead host can be placed in a jar with water and detergent, and the jar shaken vigorously to remove ectoparasites from the animal. The liquid is then poured into a funnel containing filter paper. Any mites will be strained out by the filter paper. Live hosts can be placed in cages that have wire or hardware cloth bottoms so that any mites that drop off after engorging will fall into a pan of water placed under the cage.

In the field, 12-inch squares of black paper or plastic can be placed on the ground in suspected chigger habitat for 1 to 5 minutes, after which the total number of chigger mites that congregate on the black squares is counted. Locate plates about 100 m apart. If nothing else is available, the black surface over the toes of combat boots can be used to visualize crawling chiggers. Mites can be separated from nesting material, grass, leaves and other debris with a Berlese funnel.

The wide and patchy distribution of chigger mites make their control very difficult. Vegetation can be removed mechanically or with herbicides around military encampments to make the habitat unsuitable for survival of the mites. Mite populations have been reduced by the application of residual insecticides, but this is generally not feasible over large areas. Limited applications of insecticides may be applied to the ground, vegetation, and environs of camps, buildings and paths traveled by people. Permethrin-impregnated uniforms are highly effective against crawling arthropods like chiggers.

No experimental vaccine has been developed, but weekly doses of doxycycline have been shown to be an effective prophylaxis in limited studies.

M. Plague. (Pestis, Black death)
Plague is a zoonotic bacterial disease involving rodents and their fleas, some species of which occasionally transmit the infection to man and other animals. The infectious agent, *Yersinia pestis*, causes fever, chills, myalgia, nausea, sore throat and headache. Bacteria accumulate and swelling develops in the lymph nodes closest to the infected bite. Since most fleabites occur on the lower extremities, the nodes in the inguinal region are involved in 90% of cases. The term bubonic plague is derived from the swollen and tender buboes that develop. Plague is most easily treated with antibiotics in the early stages of the disease. However, untreated bubonic plague has a fatality rate of 50%. Infection may progress to septicemic plague, with dissemination of the bacteria in the bloodstream to diverse parts of the body. Secondary involvement of the lungs results in pneumonia. Pneumonic plague is of special medical significance since respiratory aerosols may serve as a source of person-to-person transmission. This can result in devastating epidemics in densely populated areas. Pneumonic and septicemic plague are invariably fatal when untreated but respond to early antibiotic therapy. To ensure proper diagnosis, medical personnel should be aware of areas where the disease is enzootic. Plague is often misdiagnosed, especially when travelers or military personnel develop symptoms after returning from an enzootic area.

Military Impact and Historical Perspective. Epidemics of plague have been known since ancient times and have profoundly affected civilization. During the Middle Ages, Europe experienced repeated pandemics of plague. Twenty-five percent of the continent’s population died during the great pandemic of the 14th century. The last pandemic originated at the close of the 19th century in northern China and spread to other continents by way of rats on steamships.

During the Middle Ages, plague was a decisive factor affecting military campaigns, weakening besieged cities or attacking armies. During World War II, plague presented a real threat to U.S. military forces in the Mediterranean area and the Orient, but no U.S. military personnel contracted the disease. This was attributed to effective rodent control, DDT for flea control, chemoprophylaxis, and the use of preliminary plague vaccines. Severe ecological disturbances and dislocations of human populations during the Vietnam War led to outbreaks of plague, primarily in native populations. Even though plague has been declining on a worldwide basis, persistent enzootic foci can trigger the recurrence of epidemics when war or natural disasters disrupt general sanitation and health services. Presently, the threat of plague to military operations is low.

Disease Distribution. Plague is enzootic in China and Mongolia (Figure 7).

China: Foci of enzootic plague have been reported primarily from Gansu, Qinghai, and Yunnan Provinces, and from Nei Mongol, Xinjiang, and Xizang Autonomous Regions. Plague foci are primarily located in remote, rural mountainous or upland areas, and epizootics usually occur from March through May. Between 1959 and 1988, 23 outbreaks of plague involving 63 human cases were reported from Gansu Province. Most cases were acquired by hunting and handling infected marmots. *Marmota himalayana* is the primary reservoir, but *M. bobak* is also commonly infected. *Marmota himalayana* is also the primary reservoir of plague in Qinghai Province. The most common fleas collected from this marmot were *Callopsylla dolabris*, *Oropsylla silantiewi* and *Rhadinopsylla liventricosa*. Between 1958 and 1992, 391 human cases of plague were recorded in the province. Most outbreaks were associated with skinning and handling infected marmots. *Yersinia pestis* can survive for up to 3 weeks in the skin of dry marmot pelts. Nearly 50% of cases were acquired from an infected individual with pneumonic plague. Only 2.3% of cases were acquired by the bite of infected fleas. Fifteen percent of plague outbreaks in humans in Qinghai Province were caused by infected Tibetan sheep. Three biotypes of plague have been identified in the province: 1) Qinghai-Tibetan, 2) Lilian Mountain, and 3) Alton Mountain. Based on molecular analysis of *Y. pestis*, 7 independent plague foci have been identified in Yunnan Province: 1) northwest Yunnan mountain area, 2) Baoshan Basin, 3) Yingjiang river valley, 4) Longchuan river valley, 5) Nanding river valley, 6) the lower reaches of Lancang river basin, and 7) the Yuanjiang section of the Honghe river. Two enzootic cycles have been identified in the province. One involves the domestic rat, *R. tanezumi* (*R. flavipectus*) and the Oriental rat flea, *Xenopsylla cheopis*. The musk shrew, *Suncus murinus*, is another potential domestic reservoir of plague in the province. It commonly occurs in gardens and enters homes. Epizootics have occurred principally on plains or in intensively cultivated valleys or basins at an altitude of 400 to 2100 m. Most human outbreaks have been associated with unsanitary living conditions and large populations of *R. tanezumi*. Another enzootic cycle occurs in the field mouse *Apodemus chevrieri* and the vole *Eothenomys melanogaster* (*E. miletus*) in mountainous areas of Jianchuan County. The main enzootic vector is *Neopsylla specialis specialis*. Epizootics have occurred principally in *Pinus yunnanensis* forests and

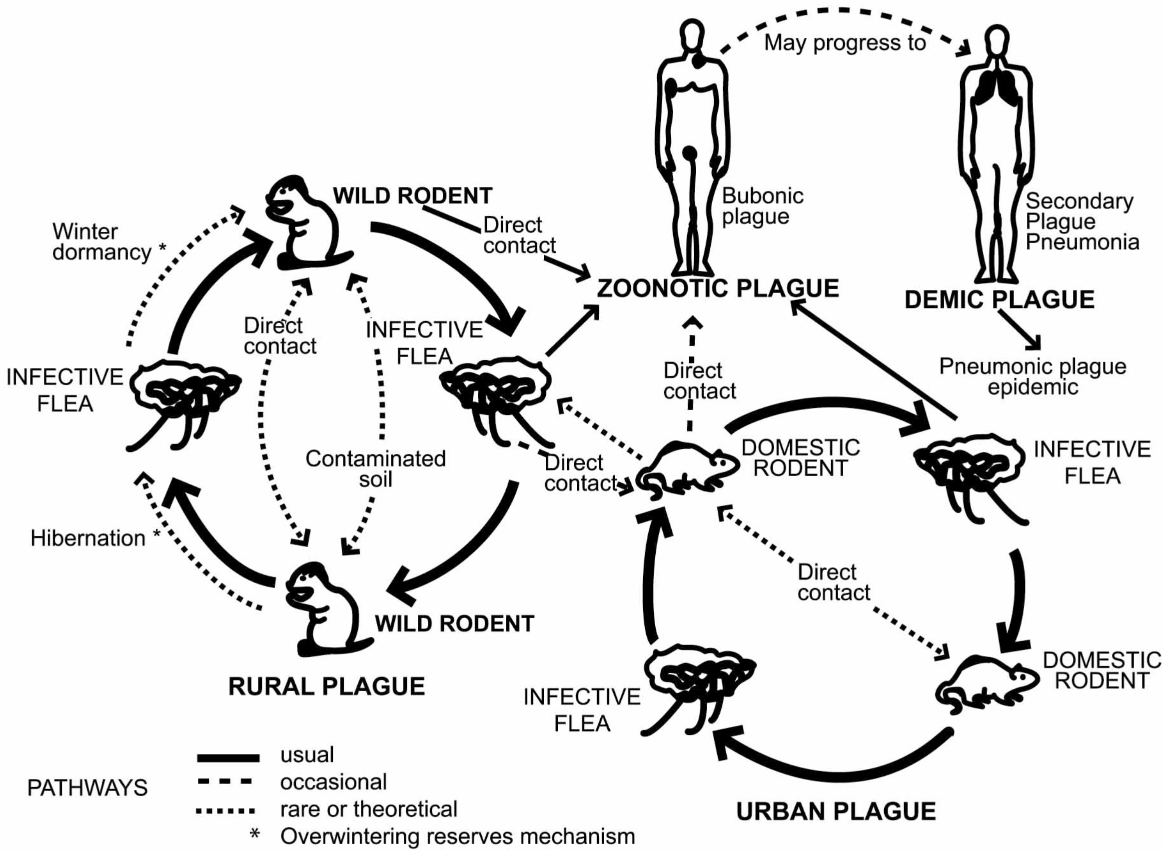
FIG. 7. DISTRIBUTION OF PLAGUE IN EAST ASIA (DARK SHADING).

mountainous cultivated land at elevations of 2500 to 3000 m. From 1952 to 1987, *Y. pestis* was isolated from 14 species of rodents and 7 species of fleas in the Nei Mongol Autonomous Region (Inner Mongolia). Jirds, especially *Meriones unguiculatus*, are the enzootic reservoirs, and *Nosopsyllus laeviceps kunzenkovi* is the primary enzootic vector. *Xenopsylla conformis* and *N. pleskei* are important secondary enzootic vectors. From 1955 to 1992, *Y. pestis* was isolated from 9 species of vertebrates and 11 species of fleas in the Xinjiang Autonomous Region. Three independent biotypes of enzootic plague were identified: 1) the northern Tainshan Mountainous districts, with *Marmota baibacina* and the suslik, *Spermophilus undulatus* (*Citellus undulatus*), as reservoirs; 2) the *S. undulatus* foci of the Pamirs and Alaishan Mountainous Districts; and 3) the *M. himalayana* foci of the Kunlun Mountainous Districts. Enzootic plague was not found in the plains and desert areas of the district. *Oropsylla silantiewi*, an ectoparasite of marmots, and *Citellophilus tesquorum sungaris*, parasitic on *S. undulatus*, are important enzootic vectors. In Xizang Autonomous Region, *Y. pestis* has been isolated from the marmot, *M. himalayana*, and the fleas *Neopsylla stevensi*, *N. specialis specialis* and *Pulex irritans*. *Xenopsylla cheopis* occurs in western Xizang along the Indian border. Additional foci of plague are indicated by isolations of *Y. pestis* from *Meriones unguiculatus* in Ningxia and Shaanxi Provinces, from *Spermophilus dauricus* in Jilin Province, and from *Microtus* spp. in Sichuan Province.

Mongolia: Three geographical foci of enzootic plague have been described for Mongolia: 1) the mountains of the northwest, 2) the Mongolian Altai, and 3) the dry steppes and desert of the southern Gobi, eastern Gobi and Sukhe-Bator. Most isolations of *Y. pestis* in Mongolia have come from the enzootic reservoirs *Marmota sibirica*, *Ochotona* spp. (pikas or mouse hares), *Spermophilus* spp., and *Lasiopodomys brandti*, although *Meriones* spp. are common. Most ectoparasitic isolations have come from the fleas of the Mongolian mouse hare, *O. pricei*. The broken terrain in many of these areas facilitates isolation of rodent populations, leading to a focal distribution of plague. The Mongolian mouse hare and the Daurian mouse hare, *O. daurica*, are the main reservoirs of plague in northwestern Mongolia. Over 30 species of fleas have been collected from these rodents. The fleas *Amphalius runatus* and *Ctenophyllus hirticrus* are the most common species collected from these hosts, although other species, such as *Frontopsylla frontalis baikal* and *C. avicitelli*, are often more abundant in their burrows and nests. Twenty-four species of fleas have been collected from Brandt's vole, *L. brandti*, in the steppes of southeastern Mongolia and northern China. The most important enzootic vectors are *Neopsylla pleskei orientalis* and *F. luculenta luculenta*.

Transmission Cycle(s). Plague is a disease of rodents. It is maintained in nature among wild rodents and their fleas (Figure 8). This zoonotic cycle is termed sylvatic, campestral, rural, or wild plague, and can be very complex, involving many rodent and flea species. In Yunnan Province, China, 136 species and subspecies of fleas have been identified. Over 60 flea species are known from northwestern Mongolia. Little is known about the biology of most wild rodent fleas. Worldwide, over 220 species of rodents have been shown to harbor *Y. pestis*. In addition, the camel and goat are susceptible to infection with plague bacteria and may play a significant

FIGURE 11. EPIDEMIOLOGICAL CYCLES OF PLAGUE



role in the dissemination of human plague when infected animals are butchered for human consumption.

Some rodents are highly susceptible to infection, resulting in high mortality. Although large numbers of dead and dying rodents are a good indication of an epizootic of plague, rodent species that are resistant to infection are more important in maintaining the zoonotic cycle. Most cases in military personnel would probably occur as a result of intrusion into the zoonotic cycle during or following an epizootic of plague in wild rodents. Domestic cats and dogs may carry infected rodent fleas into buildings or tents. Cats may occasionally transmit infection by their bites or scratches, or by aerosol when they have pneumonic plague. Troops should not be allowed to adopt cats or dogs as pets during military operations.

The entry of wild rodents or their infected fleas into human habitations can initiate an epizootic among commensal rodents, primarily *Rattus* spp., which are highly susceptible to infection. Close association of humans with large populations of infected commensal rodents can result in an urban cycle of plague. A similar cycle can occur in military cantonments experiencing large infestations of commensal rodents. The most important vector of urban plague worldwide is the Oriental rat flea, *Xenopsylla cheopis*. The human flea, *Pulex irritans*, is a secondary vector in East Asia.

The most frequent route of plague transmission to humans is by the bite of infected fleas. Fleas often exhibit a host preference, but most species of medical importance readily pass from one host to another. A lack of absolute host specificity increases the potential for infection and transmission of pathogens. Plague may also be acquired by handling tissues of infected animals or humans, and by person-to-person transmission of pneumonic plague. Additionally, crushed infected fleas and flea feces inoculated into skin abrasions or mucous membranes can cause infection. Not all flea species are competent vectors. The vector competence of the Oriental rat flea is attributed to enzymes produced by the plague bacilli that cause blood to coagulate in the flea's digestive tract. The flea attempts to clear the blockage in its digestive tract by repeated efforts to feed. In the process, plague bacilli are inoculated into the host. Fleas may remain infective for months when temperature and humidity are favorable. *Xenopsylla cheopis* may require 2 to 3 weeks after an infective bloodmeal before it can transmit plague bacilli.

Vector Ecology Profiles.
Xenopsylla cheopis occurs mostly in urban areas, in association with its rodent hosts. However, it may occur sporadically in villages when rats are present. Adult fleas feed exclusively on blood and utilize blood protein for egg production. After feeding on a rodent, the female Oriental rat flea lays several eggs (2 to 15). Hundreds of eggs may be laid during the entire life span. Oviposition most often occurs on the hairs of the host, but the eggs drop off and hatch in the nest or its environs. In locally humid environments, such as rodent burrows, eggs may hatch in as little as 2 days. Larvae grow rapidly when temperature and relative humidity are above

25 C and 70%, respectively; they live in the nest, feeding on dried blood, dander, and other organic materials. The larval stages can be completed in as little as 14 days (at 30 to 32 C), or as many as 200 days when temperatures drop below 15 C or when nutrition is inadequate. Mature larvae pupate in cocoons, loosely attached to nesting material. Adult emergence may occur in as little as 7 days or as long as a year and is stimulated by carbon dioxide or host activity near the cocoon. Adult fleas normally await the approach of a host rather than actively search for one. Fleas feed on humans when people and rodents live close together, but man is not a preferred host. However, if rat populations decline suddenly due to disease or rat control programs, these fleas readily switch to feeding on humans. The life span of adult *X. cheopis* is relatively short compared to that of other flea species, often less than 40 days. Flea populations increase rapidly during periods of warm, moist weather.

Pulex irritans, commonly termed the human flea, occurs mainly among lower socioeconomic groups. It is a secondary vector of plague in East Asia and is more widely distributed in China than in Mongolia. The life cycle of the human flea is similar to that of the Oriental rat flea. Despite its common name, *P. irritans* has a low to moderate preference for humans and is more likely to feed on a variety of rodents, including mice, susliks, voles, pikas, and gerbils, maintaining the enzootic plague cycle among these hosts. Where swine occur, the human flea prefers this host to humans. Domestic animals such as dogs also serve as hosts, but in the absence of preferred hosts, this flea readily feeds on humans and is frequently found in human habitations. *Pulex irritans* can live over one year on its preferred hosts. It can survive unfed for several months.

Vector Surveillance and Suppression. The methods of flea surveillance depend upon the species of flea, the host, the ecological situation, and the objective of the investigation. Fleas can be collected from hosts or their habitat. The relationship of host density to flea density should be considered in assessing flea populations. It has been common practice for years to use a flea index (average number of fleas per host), especially in studies of rodent fleas. For *X. cheopis*, a flea index > 1.0 flea per host is considered high. The flea index has many limitations, since only adults are considered and then only while they are on the host. Fleas are recovered by combing or brushing the host or by running a stream of carbon dioxide through the fur while holding the host over a white surface.

Flea abundance in the environment can be determined by counting the number of fleas landing or crawling in 1 minute on the lower parts of the legs of the observer. The trouser legs should be tucked into the socks to prevent bites. Flea populations can also be estimated by placing a white cloth on the floor in buildings or on the ground in rodent habitat and counting the fleas that jump onto the cloth. Various flea traps have been devised. Some use light or carbon dioxide as an attractant or stimulant. Sifting and flotation of rodent nesting materials or of dust and debris from infested buildings are also effective methods of collecting fleas from the environment.

Serologies of wild carnivores are sensitive indicators of enzootic plague. Fleas and tissues from suspected reservoirs or humans may be submitted for plague analysis to the Centers for Disease Control and Prevention, National Center for Infectious Diseases, Division of Vector-borne Infectious Diseases, P.O. Box 2087, Foothills Campus, Fort Collins, Colorado 80522. Blood samples are easily collected on Nobuto paper strips, dried and submitted to a laboratory for testing. Consult TG 103, Prevention and Control of Plague.

Control of enzootic plague over large areas is not feasible. Control efforts should be limited to foci adjacent to urban areas, military encampments, or other areas frequented by military personnel. If possible, cantonment sites should not be located in wild rodent habitats. Fleas quickly leave the bodies of dead or dying rodents in search of new hosts. Consequently, flea control must always precede or coincide with rodent control operations. Application of insecticidal dusts to rodent burrows is effective in reducing flea populations, but it is very labor intensive. Fleas can be controlled by attracting infested rodents to bait stations. The stations may incorporate an insecticidal dust that rodents pick up while feeding or a rodent bait containing a systemic insecticide that fleas ingest when taking a bloodmeal. However, baiting with systemic formulations may pose environmental risks.

Urban plague control requires that rodent runs, harborages and burrows be dusted with an insecticide labeled for flea control and known to be effective against local fleas. Insecticide bait stations can also be used. Rat populations should be suppressed by well-planned and intensive campaigns of poisoning and concurrent measures to reduce rat harborages and food sources. Buildings should be rat-proofed to the extent possible to prevent rats from gaining entry. Domestic rodent control is discussed in Technical Guide (TG) 138, Guide to Commensal Rodent Control. Insecticides recommended for flea control are listed in TIM 24, Contingency Pest Management Guide.

Military personnel, especially those involved in rodent control, should use the **personal protective measures** discussed in TIM 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance, and outlined in Appendix E. Active immunization with a vaccine of killed bacteria confers protection against bubonic plague (but not pneumonic plague) in most recipients for several months. Booster injections are necessary every 6 months. The efficacy of plague vaccine in humans has not been demonstrated in a controlled trial, so vaccination should not be relied upon as the sole preventive measure.

N. Murine Typhus. (Flea-borne typhus, Endemic typhus, Shop typhus)
The infectious agent, *Rickettsia typhi* (formerly *R. mooseri*), causes a debilitating illness with high fever and a maculo-papular rash. The incubation period ranges from 1 to 2 weeks, and clinical symptoms may last up to 2 weeks in untreated cases. Mortality is very low, and serious complications are infrequent. The disease is easily treated with antibiotics. Absence of louse infestation, seasonal distribution, and the sporadic occurrence of murine typhus help to

differentiate it from epidemic typhus. Murine typhus is often unrecognized and substantially underreported in most endemic areas. It is not a notifiable disease in most countries.

Military Impact and Historical Perspective. Confusion in diagnosis between murine typhus and closely related diseases may occur. Prior to World War II, murine typhus was not distinguished from the epidemic form, and its importance in prior wars is unknown. During World War II, there were 786 cases in the U.S. Army, with 15 deaths. Only 34 cases were recorded in the China-Burma-India theater. There are little available data on the incidence of murine typhus during military operations in Korea and Vietnam. During the Vietnam War, murine typhus was concentrated in port cities and incidence seemed low. However, retrospective studies indicated that *R. typhi* was probably responsible for a large proportion of fevers of unknown origin experienced by Americans during that conflict. The disease is most common in lower socioeconomic classes and increases when wartime disruptions or mass migrations force people to live in unsanitary conditions in close association with domestic rodents. However, murine typhus has not been a major contributor to disease rates in disaster situations. Because of the sporadic incidence of murine typhus, it is difficult to confidently predict the potential impact of this disease on future military operations, although any such impact would probably be minimal.

Disease Distribution. Murine typhus is one of the most widely distributed arthropod-borne infections and is endemic in many coastal areas and ports throughout the world. Human cases occur principally in urban areas, where commensal rodent infestations are common, although infected rodents have been collected from rural villages. Foci occur countrywide wherever rats are common, and transmission is year-round in tropical and subtropical regions. Murine typhus usually occurs in the summer and fall, while epidemic typhus generally occurs during colder months. Only sporadic cases have been reported in East Asian medical literature. However, serological surveys indicate that infection with *R. typhi* is common in some parts of the region. A 1989 serological study of febrile patients in South Korea found that 18% had antibodies to *R. typhi*. Antibodies to *R. typhi* were found in 24% of local residents in Tainan, Taiwan, in the early 1990s and in 33% of people tested in Ali Prefecture, Tibet, during the mid 1990s. Cases of murine typhus have been reported among fur trappers who handle marmots in Mongolia. In China, fall outbreaks of murine typhus from 1980 to 1982 were associated with storage of the grain harvest, particularly in Henan Province along the Yellow River, where large populations of rats became abundant.

Transmission Cycle(s). Murine typhus is a zoonotic infection associated with domestic rats (*Rattus rattus* and *R. norvegicus*) and vectored by their fleas and the spiny rat louse, *Polyplax spinulosa*. *Rickettsia typhi* has also been isolated from *R. tanezumi* (*R. flavipectus*) in Yunnan Province. The Oriental rat flea, *X. cheopis*, is the most important vector. Neither rodents nor their ectoparasites are affected by infection with *R. typhi*. Inoculating crushed fleas or infective flea feces into the skin at the bite site transmits the disease. Scratching fleabites increases the

likelihood of infection, but *R. typhi* is rarely transmitted directly by fleabite. Other routes of infection are inhalation of dry flea feces containing rickettsiae (which may remain infective for months), and ingestion of food contaminated by rodent urine. Murine typhus is not transmitted from person to person. The risk of transmission is year-round but peaks during the warm months in northern parts of East Asia.

Although the rat-flea-rat cycle is still the major source of human infection, murine typhus exists in some endemic foci where commensal rodents are absent. In suburban areas of Texas and southern California, the classic enzootic cycle has been replaced by a peridomestic animal cycle involving free-ranging cats, dogs and opossums and their fleas. In the Dinaric beech-fir forest of southern Slovenia, *Monopsyllus sciurorum* fleas collected from the nests of the fat doormouse, *Glis glis*, were found infected with *R. typhi*. The widespread distribution of this sylvatic flea species and its presence on other mammalian and avian hosts suggests that murine typhus may exist in unrecognized enzootic cycles.

Vector Ecology Profiles.
The primary vector is the Oriental rat flea, *X. cheopis*. Potential secondary vectors for humans are the cat and dog fleas, *Ctenocephalides felis* and *C. canis*, as well as the human body louse, *Pediculus humanus humanus*. The northern rat flea, *Nosopsyllus fasciatus*, spiny rat louse, *Polyplax spinulosa*, and tropical rat mite, *Ornithonyssus bacoti*, are vectors that maintain the enzootic cycle of the disease. *Rickettsia typhi* has been isolated from the rat fleas *Monopsyllus anisus* and *Leptopsylla segnis* collected from *R. flavipectus* in Yunnan Province. These rodent ectoparasites may also play a role in the enzootic cycle of murine typhus in China. Flea biology is discussed under plague. The biology of human body lice is discussed under epidemic typhus.

Polyplax spinulosa, the spiny rat louse, is closely associated with its rodent hosts. Female lice attach eggs to rodent hairs, and all developmental stages live exclusively on rodents. Lice are only transferred from rodent to rodent by body contact. These lice feed on rat blood but do not feed on humans.

Ornithonyssus bacoti, the tropical rat mite, lives on commensal and other rodents throughout East Asia and feeds on blood and other fluids that ooze from its tiny bite wounds. Engorged females start laying eggs within 2 days of feeding and continue to lay groups of eggs for 2 to 3 days. Eggs hatch in 1 to 2 days and develop into larvae, followed by protonymphs and deutonymphs. The entire life cycle, from egg to adult, requires only 5 to 6 days. These mites will readily infest humans if their rodent hosts are suddenly eliminated, or if humans live in close association with rodent nests.

The northern rat flea, *N. fasciatus*, occurs where commensal rodents are found, particularly *R. norvegicus* and *R. rattus*. It has been recorded from China, Japan and the Korean Peninsula, but it is not as common in the Far East as it is in Europe and North America. *Nosopsyllus fasciatus*

lays its eggs in the nests or burrows of its hosts. Larvae have the unique habit of attaching to the abdomen of an adult flea and ingesting fecal blood as it passes from the anus of the adult.

Vector Surveillance and Suppression. See this section under plague.

O. Epidemic Typhus.

Epidemic typhus is a severe disease transmitted by the human body louse, *Pediculus humanus humanus*. The infectious agent is the bacterium *Rickettsia prowazekii*. It causes high mortality, particularly in populations weakened by malnutrition. Case fatality rates normally vary from 10% to 40% in the absence of specific therapy. Onset is usually sudden and marked by fever, headache, and general pains followed by a rash that spreads from the trunk to the entire body. Untreated cases of epidemic typhus may last up to 3 weeks. Many humans who contract typhus retain some rickettsiae for the rest of their lives. Under certain stressful conditions or reduced immunity, they may relapse and develop a milder form of typhus known as Brill-Zinsser disease.

Military Impact and Historical Perspective. Epidemics of typhus have changed the course of history. One author stated that the louse has killed more soldiers than all the bullets fired in war. During 1812, in one of the worst disasters in military history, over half of Napoleon's army perished from epidemic typhus during the invasion of Russia. During the first year of World War I, typhus started as an epidemic in the Serbian Army. In 6 months, 150,000 people were dead from the disease, including 50,000 prisoners of war and one-third of Serbian physicians. From the end of the war through 1923, an estimated 30 million cases of epidemic typhus occurred in Russia and Europe, with over 300,000 deaths. During World War II, there were severe epidemics of typhus in some endemic areas, including Bucovina, in northeast Romania, and neighboring Moldova. There were also hundreds of thousands of cases in Poland during the war as well as large epidemics in Yugoslavia. From 1941 to 1944, there were over 132,000 cases in urban areas of French North Africa. More than 91,000 cases occurred in Egypt during the same period. Despite this incidence, U.S. Army personnel experienced only 30 cases of typhus with no typhus deaths in the North African-Middle East-Mediterranean zone during the years 1942 to 1945. When Allied forces landed in Italy in 1943, a typhus epidemic in Naples was ravaging the city of 1 million. Death rates reached 80%. An effective delousing campaign, chiefly using DDT, was waged. This marked the first time in history that an epidemic of typhus did not exhaust itself but instead was terminated by human action. The U.S. Army achieved a remarkable record of low morbidity with no fatalities from epidemic typhus in World War II. This was accomplished by taking effective protective measures against the disease and through the work of the U.S. Typhus Commission, established by the Secretary of War on October 22, 1942. DDT was used extensively during a typhus epidemic in Japan and Korea in the winter of 1945 to 1946. Over 2 million Koreans and Japanese were treated with DDT powder. Epidemic typhus was not a problem in U.S. military personnel during the Korean War, although infestation of body lice in Korean civilian and military personnel, as well as prisoners of war, was a major problem for U.S. military entomologists due to resistance of body lice to DDT.

The development of modern antibiotics and insecticides has reduced the threat of this disease to military forces. However, the short incubation period and severe clinical symptoms of epidemic typhus should be of concern to medical personnel when dealing with large concentrations of refugees and prisoners of war. *Rickettsia prowazekii* has the most serious epidemic potential of all rickettsiae, and the emergence and dissemination of body lice can be very rapid under favorable conditions. In a refugee camp in Goma, Zaire, all 800,000 refugees became infested within 1 month.

Disease Distribution. Epidemic typhus is more common in temperate regions and in the cooler tropics above 1,600 m. It is absent from lowland tropics. It usually occurs in mountainous regions where heavy clothing is worn continuously, such as the Himalayas, Pakistan, Afghanistan, and the highlands of Ethiopia. The incidence of epidemic typhus has been steadily declining in the last 2 decades. The majority of recent cases have occurred in Africa, primarily in Ethiopia, with most of the remainder occurring in Peru and Ecuador. During 1997, a large outbreak was reported in Burundi in which 100,000 people were infected. A small outbreak was observed in Russia in the same year. During 1998, small outbreaks were recorded in Peru, and an isolated case occurred in Algeria.

Body lice are common human parasites in mountainous temperate areas of East Asia and the colder northern parts of the region, such as Mongolia, Inner Mongolia, North Korea, and extreme northwestern China. Fifteen epidemics of typhus occurred in China between 1850 and 1934. Seven of the epidemics were associated with floods, famine or other natural calamities. Over 100,000 cases of epidemic typhus occurred in Chinese citizens between 1940 and 1946 as a result of the extensive social disruption associated with World War II. Since 1949, 2 major outbreaks of epidemic typhus have been documented: one in the 1950s (Guizhou, Sichuan, and Yunnan Provinces) and the other in the 1960s (Heilongjiang, Jilin, and Liaoning Provinces). Famine and mass migration of humans played important roles in these outbreaks. Cases were reported near the mountainous borders of Guizhou, Yunnan, and Sichuan Provinces in the 1970s, where cold weather, poverty and poor sanitation were responsible for body louse infestations. In 1979 a focus of epidemic typhus was studied in northeastern Mongolia, where 70% of the population in some areas had typhus antibodies. Nearly 33% of the human sera tested in Ali Prefecture, Tibet, during the mid 1990s had typhus antibodies. However, serological surveys reported in the literature are difficult to interpret because of extensive cross-reactivity between epidemic and murine typhus. An emphasis on preventive medicine and a general improvement in living conditions in China have resulted in a dramatic reduction in incidence of epidemic typhus. Outbreaks of louse-borne typhus have not been recorded since 1968 in South Korea. However, epidemic typhus may be a public health threat in North Korea due to famine and declining standards of living.

Transmission cycle(s). The head louse, *Pediculus humanus capitis,* and the crab louse, *Pthirus pubis*, can transmit *R. prowazekii* experimentally, but epidemics have always been associated

with the body louse, *P. h. humanus*. Humans are reservoirs of the pathogen and the only hosts for the lice. Transmission of the disease occurs when individuals wear the same clothes continuously under crowded, unsanitary conditions. Major epidemics have been associated with war, poverty and natural disasters. Persons in cold climates are more likely to acquire epidemic typhus when they are unable to bathe or change clothes for long periods of time.

Lice become infective 5 to 7 days after a bloodmeal from an infected human. During subsequent bloodmeals, the louse defecates and rickettsiae are excreted in the feces. Louse bites are irritating, and scratching by the host produces minor skin abrasions, which facilitate entry of the pathogen from feces or crushed body lice. *Rickettsia prowazekii* can survive desiccation for several weeks. Louse feces are extremely dry and powdery, so infection may also occur by inhalation of infective louse feces.

The survival of *R. prowazekii* between outbreaks is of interest, since there is no transovarial transmission and lice die from the infection. Individuals who recover from the initial infection and relapse years later with Brill-Zinsser disease are considered the primary reservoir. Lice feeding on such patients can become infected and transmit epidemic typhus to other individuals. A sylvatic cycle of *R. prowazekii* has been recognized in the southeastern United States, where flying squirrels and their ectoparasites (the flea *Orchopeas howardii* and the louse *Neohaematopinus sciuropteri*) are naturally infected. The louse is host specific, but *O. howardii* has an extensive host range, which includes humans. Sporadic human cases have occurred in houses harboring flying squirrels. The significance of this finding to the epidemiology of epidemic typhus in other areas is not known.

Vector Ecology Profiles.
Human lice spend their entire life cycle (egg, 3 nymphal stages and adult) on the host. Eggs of body lice are attached to clothing at a rate of about 5 to 8 eggs per female per day. Lice must mate before egg laying, since females cannot store sperm. At 29°C to 32°C, eggs hatch in 7 to 10 days. The maximum time eggs can survive unhatched is 3 to 4 weeks, which is important when considering the survival of lice in infested clothing and bedding. A bloodmeal is required for each of the 3 nymphal molts and for egg production in adults. The nymphal stages are passed in 8 to 16 days. Louse populations have the potential to double every 7 days. Adults live about 2 weeks and feed daily. Infestations of lice cause considerable irritation and scratching, which may lead to skin lesions and secondary infections. Body lice are commonly found in the seams and folds of clothing. Lice tolerate only a narrow temperature range and will abandon a dead host or one with a body temperature of 40°C or above. This contributes to the spread of lice and louse-borne disease. Humidity is also critical because lice are susceptible to rapid dehydration. The optimal humidity for survival is between 70% and 90%. Body lice cannot survive at a relative humidity below 40%. They can survive without a host for only a few days and are spread by intimate personal contact or contact with infested clothing or other items.

Vector Surveillance and Suppression. The incidence of head lice has been increasing worldwide. Body louse infestations have declined with higher standards of living, although infestations are still common in some areas of East Asia, especially at high elevations where heavy clothing is worn and bathing is infrequent. The prevalence of body lice reflects the socioeconomic level of the society. The incidence of body lice has increased in some countries due to war and social change. Infestations with body lice are increasingly being reported among the homeless and deprived populations in inner cities of developed nations. Military personnel should avoid close personal contact with infested persons and their belongings, especially clothing and bedding.

Surveillance for body lice consists of examining individuals and their clothing for lice or nits (eggs). The population density of body lice may be very high, but usually only a few lice are observed on an individual. Body lice are frequently found around the waistbands of clothing. Heavily bitten areas, such as the base of the thorax, the groin and the flanks of the body, may become darker. This characteristic skin coloration is often referred to as vagabond's disease.

Dry cleaning or laundering clothing or bedding in hot water (55°C for 20 minutes) will kill eggs and lice. Control of epidemics requires mass treatment of individuals and their clothing with effective insecticides. The permethrin-treated BDU is extremely effective against lice. Since lice cannot survive away from the human host, application of insecticides to buildings, barracks or other living quarters is not necessary. Mass louse control could be hampered by insecticide resistance. Resistance to common pediculicides, particularly DDT and gamma BHC (lindane), is widespread in East Asia. Pyrethroid lotions and shampoos have been widely used in some areas to control head lice, and reports of pyrethroid resistance are increasing. Compounds such as ivermectin, taken orally to eradicate lice, have been investigated experimentally but are not currently registered for that use.

Production of typhus vaccine in the United States has been discontinued, and there are no plans for commercial production of a new vaccine. Vaccination against typhus is not required by any country as a condition of entry. The U.S. military no longer has the equipment to perform mass delousing as it has done in the past. Consult TIM 6, Delousing Procedures for the Control of Louse-borne Disease During Contingency Operations, for more information on the surveillance and control of body lice.

P. Relapsing Fever (louse-borne). (Epidemic relapsing fever)
Louse-borne relapsing fever is caused by the spirochete *Borrelia recurrentis*. The symptoms and severity of relapsing fever depend on the immune status of the individual, geographic location, and strain of *Borrelia*. The incubation period in an infected host ranges from 2 to 14 days. The disease is characterized by a primary febrile attack followed by an afebrile interval and 1 or more subsequent attacks of fever and headache. Intervals between attacks range from 5

to 9 days. In untreated cases, mortality is usually low but can reach 40%. Infection responds well to treatment with antibiotics.

Military Impact and Historical Perspective. Major epidemics of louse-borne relapsing fever occurred during and after World War I in Russia, Central Europe and North Africa. After the war, relapsing fever was disseminated through large areas of Europe, carried by louse-infested soldiers, civilians and prisoners of war. Between 1910 and 1945, there were an estimated 15 million cases and nearly 5 million deaths. Large outbreaks of relapsing fever were common during and after World War II, when epidemics in North Africa produced an estimated 1 million cases and some 50,000 deaths. However, U.S. forces were largely spared. There were only 70 cases reported from the China-Burma-India theater and most of these occurred in China. One death due to louse-borne relapsing fever was reported in U.S. military personnel during the Korean War. During the Vietnam War, outbreaks of louse-borne relapsing fever occurred in the Democratic People's Republic of Vietnam.

Disease Distribution. From 1960 to 1980, louse-borne relapsing fever flourished primarily in the Sudan, Somalia, Ethiopia and Eritrea. Ethiopia reported the highest number of cases, with an estimated 10,000 per year. Relapsing fever is also believed to persist in the Peruvian Andes and the Himalayas. Epidemics usually occur in the cold season, among poor people with inadequate hygiene. There are no recent published reports of louse-borne relapsing fever in East Asia, although sporadic cases are believed to occur.

Transmission Cycle(s). The body louse, *P. h. humanus*, is the vector of *B. recurrentis*. After the louse feeds on infective blood, the spirochetes leave the digestive tract and multiply in the insect's body cavity and other organs. They do not invade the salivary glands or the ovaries and are not found in the feces. Bites and fecal deposits cannot transmit the pathogen, and transovarial transmission does not occur. Human infection results when a louse is crushed and *Borrelia* spirochetes are released. The spirochetes may be scratched into the skin or come in contact with mucous membranes, but there is evidence that *B. recurrentis* can penetrate unbroken skin. Since infection is fatal to the louse, a single louse can infect only 1 person. However, *B. recurrentis* can survive for some time in a dead louse. Outbreaks of louse-borne relapsing fever require high populations of body lice. Lice leave febrile patients in search of new hosts, and this behavior contributes to the spread of disease during an epidemic.

Humans are the only known reservoir for *B. recurrentis*. Mechanisms of survival during non-epidemic periods are unknown. The life cycle of the body louse is less than 2 months, and in the absence of transovarial transmission *B. recurrentis* cannot survive in the louse population.

Vector Ecology Profiles. See this section under epidemic typhus.

Vector Surveillance and Suppression. See epidemic typhus. Also consult TIM 6, Delousing Procedures for the Control of Louse-borne Disease During Contingency Operations, for more information on the surveillance and control of body lice.

Q. Other Arthropod-borne Viruses.

Many enzootic arboviruses are circulating in East Asia, but little is known about them. Available epidemiological information indicates that they would have a minor impact on military operations. However, medical personnel should be aware of these arboviruses because they will frequently be treating fevers of unknown origin and, in serological tests, may see reactions to closely related viruses known to cause disease in the region.

Getah virus is a member of the genus *Alphavirus* in the family Togoviridae. It has been frequently isolated from mosquitoes, and seroepizootiological studies indicate that the virus is widespread, ranging from Eurasia to Southeast and East Asia, the Pacific islands and Australasia. Getah virus has caused illness in horses in Japan and has been isolated from *Culex tritaeniorhynchus*. In 1956, Sagiyama virus was isolated from mosquitoes in Japan. Recent molecular studies have shown this virus to be closely related if not identical to Getah virus. Serological studies in Japan have found antibodies to Getah virus in over 50% of the horses tested, and a high prevalence of antibodies has been demonstrated in pigs, horses and goats on Hainan Island, China. The natural transmission cycle of this alphavirus is not known, but it is not considered a public health threat. Antibodies to Getah virus without human disease have been reported in several areas of East Asia, including Japan, China and Hong Kong.

Sindbis virus also belongs to the genus *Alphavirus*, family Togaviridae. It is closely related to the Western equine encephalitis complex. The incubation period is less than a week and symptoms may include fever, headache, rash, and joint pain. Syndromes resulting from Sindbis virus infection have been called Ockelbo disease in Sweden, Pogosta disease in Finland, and Karelian fever in the former Soviet Union. No fatal cases have been reported. Sindbis virus is one of the most widely distributed of all known arboviruses. Studies have demonstrated Sindbis virus transmission in most areas of the Eastern Hemisphere. A wide range of wild and domestic vertebrate species are susceptible to infection with Sindbis virus. Evidence implicates bird-feeding mosquitoes of the genus *Culex* as the vectors of Sindbis virus in enzootic and human infections. Its status in East Asia is unclear. Sindbis virus has been isolated from *Cx. tritaeniorhynchus* in Taiwan, and a Sindbis-like virus was recently isolated from a pool of *Anopheles* mosquitoes collected in Xinjiang, China.

VI. Militarily Important Vector-borne Diseases with Long Incubation Periods (>15 days).

A. Leishmaniasis.

This potentially disfiguring and sometimes fatal disease is caused by infection with protozoan parasites of the genus *Leishmania*. Transmission results from bites of infected phlebotomine sand flies. Incubation in humans may take as little as 10 days or more than 6 months. Symptoms include ulcerative cutaneous lesions (cutaneous leishmaniasis or CL), lesions in the mucosal areas of the mouth and/or nose (mucocutaneous leishmaniasis or MCL), and internal pathological manifestations resulting in fever, swollen lymph glands, anemia, enlargement of the liver and spleen, and progressive emaciation and weakness (visceral leishmaniasis or VL).

CL (Baghdad boil or Oriental sore), caused by infection with *Le. tropica*, typically appears as a nonhealing ulcer and is often referred to as anthroponotic cutaneous leishmaniasis (ACL). The lesion usually develops within weeks or months of an infected sand fly bite and slowly evolves from a papule to a nodule to an ulcer. Cutaneous lesions may resolve quickly (2 to 3 months) without treatment or they may become chronic (lasting months to years) and will seldom heal without treatment. Scarring is associated with healing. In endemic areas, such scars are common among rural and urban populations. Lifelong immunity to the infecting *Leishmania* species normally results.

CL, caused by *Le. major*, is often referred to as zoonotic cutaneous leishmaniasis (ZCL) and typically appears as one or more wet-looking, nonhealing ulcers. The lesion(s) usually develop within weeks after sand fly bites and quickly evolve from papules to open wet sores with raised, reddened edges. Lesions normally heal spontaneously and provide lifetime immunity against that species of *Leishmania*. Scars associated with healing are often evident in rural populations of East Asia.

VL (Kala-azar, Dum Dum fever), caused by *Le. infantum* and *Le. donovani*, is a severe form of leishmaniasis, with as much as 95% mortality in untreated cases. It is a chronic disease that, without treatment, is marked by fever (2 daily peaks), weakness and, as the parasites invade internal organs, weight loss coupled with enlargement of spleen and liver that may resemble severe malnutrition. It should be noted that cutaneous lesions may also be seen in human visceral leishmaniasis cases, but the chronic visceralizing nature of the disease is the main concern. In East Asia, VL is usually a disease of young children and the elderly. The increasing incidence of AIDS has made many people more susceptible to VL and the complications of this and other infectious and vector-borne diseases. Viscerotropic *Le. tropica* has also been reported and was described in veterans of the Persian Gulf War. The incubation period for VL is usually 4 to 6 months but may be as short as 10 days or as long as 2 years. By the time the disease is diagnosed, patients have usually forgotten any contact with sand flies. Epidemics of VL often follow conditions of severe drought, famine or disruption of native populations by wars that produce large numbers of refugees. In Sudan, between the years 1991 and 1996, there were

reports of 10,000 treated cases and an estimated 100,000 deaths from untreated cases of VL due to the shortage of health services.

Military Impact and Historical Perspective. The parasite responsible for The Black Sickness (Kala-azar) or Dum Dum Fever (named for the Indian city of Dum Dum) was described in 1903 by William Leishman on the basis of a case in a British soldier assigned to Dum Dum. Also in 1903, Charles Donovan reported the same parasite from a splenic puncture of a British soldier, who had been assigned to troop duty in India and was sick with the Black Sickness. The first identification of an infected sand fly, and the first proven transmission of the parasite by the bite of the sand fly vector *Phlebotomus argentipes*, were accomplished by military medical personnel in India. Leishmaniasis is a persistent health threat to U.S. military personnel because troops deploy or conduct military exercises in locations where the disease is endemic. The potential for this disease to compromise mission objectives is significant. Soldiers exposed to sand fly bites while deployed to East Asia are highly susceptible to infection with *Leishmania tropica*. Immunity among U.S. military personnel is essentially nonexistent, and recovery from CL does not confer immunity to VL. In the Karum River Valley of Iraq during World War II, U.S. forces suffered 630 cases of VL in a three-month period. Accurate information is not available for incidence of cutaneous leishmaniasis, since most cases were treated as outpatients. From 1990 to 1991, 12 cases of VL due to *Le. tropica* were diagnosed when 697,000 allied soldiers were deployed to the Arabian Peninsula during Operations Desert Shield and Storm. Even though no fatalities were associated with leishmaniasis in this deployment, new lessons were learned that could affect future military deployments. Before the Persian Gulf War, eastern Saudi Arabia was not known to be endemic for visceral leishmaniasis, and *Le. tropica* was not convincingly shown to produce visceral disease. More importantly, the potential for leishmaniasis to cause post-deployment diagnostic problems and threaten blood supplies had not been anticipated. Returnees from the Persian Gulf War were barred from donating blood for up to 2 years, severely impacting blood supplies.

Diagnosis of leishmaniasis is difficult at best, and providing proper care for service members who may have been exposed or infected is a long, costly and complex process. Treatment usually requires 20 or more days and consists of injections with pentavalent antimony (Pentostam). Because this drug is not registered for use in the U.S., it must be administered under an experimental protocol at an approved medical treatment facility. Estimated leishmaniasis-related costs can exceed U.S. $17,000 per patient, with an average of 92 lost duty days per patient. Other important but less quantifiable costs include loss to the unit, personal distress, and delay of career progression.

Disease Distribution. There is no risk of transmission of leishmaniasis in Taiwan, Japan, Macau, Hong Kong or the Korean peninsula. However, the close proximity of Macau, Hong Kong and North Korea to endemic areas of leishmaniasis increases the risk of endemic

transmission within these areas of East Asia. Imported cases of leishmaniasis are frequently reported.

Anthroponotic (human-to-human) transmission of CL due to *Le. tropica* occurs in urban centers and rural highland villages of western China. The disease is widespread in areas with a temperate climate (eastern and southeastern China), as well as those with an arid, cold climate (northcentral China including Inner Mongolia). Zoonotic (rodent to human) CL transmission due to *Le. major* occurs in western China to southwestern Mongolia in small villages or rural areas where four species of *Phlebotomus* maintain wild rodent leishmaniasis in gerbil and mouse populations. *Phlebotomus alexandrei*, *P. andrejievi*, *P. causicus* and *P. mongolensis* are the rodent-feeding sand flies that are suspected human vectors. Zoonotic CL is focally endemic and has been described as one of the major public health problems in southern Mongolia, where the reservoir is the great gerbil, *Rhombomys opimus*, and *Meriones* spp. In 1994, a form of rodent leishmaniasis, *Le. gerbilli*, isolated from great gerbils was found to cause pathogenic ulceration of the dermis in monkeys and human volunteers. It is vectored by *P. smirnovi* among rodents and people in Karamay, northwestern China, and southern Mongolia.

VL due to *Le. infantum* occurs in the Mediterranean Basin countries of North Africa, the Middle East and southern Europe, and in East Africa, South Central Asia, and East Asia. Its presence in China was first confirmed after the autopsy of a German soldier in 1909, and it was recognized as one of the most serious parasitic diseases in the country. In China, four species of phlebotomine sand flies have been incriminated as vectors of *Le. infantum* (*Phlebotomus chinensis*, *P. longiductus*, *P. sichuanensis* and *P. smirnovi*). VL occurs from western China across the country to eastern China and the suburbs of Beijing. *Leishmania donovani* is transmitted by four species of sand flies (*P. alexandrei*, *P. chinensis*, *P. caucasicus* and *P. mongolensis*) in western China and southern Mongolia. VL is highly endemic in parts of China, where transmission is year-round, though risk is elevated during the peak of sand fly activity from April through October. *Phlebotomus chinensis* has the widest distribution and is a suspected vector of *Le. donovani* and a proven vector of *Le. infantum*. *Phlebotomus chinensis* may actually be two or more cryptic species that must be identified before their distributions can be clearly defined. Natural infection rates of field-collected flies can be high for certain phlebotomines. Over 2.0% of *P. alexandrei* and 5.7% of *P. smirnovi* have been found infected in some endemic areas. An endophilic and anthropophilic species such as *P. alexandrei*, with high natural infection rates, indicates a risk of VL epidemics caused by *Le. donovani* or *Le. infantum* in areas of western Xinjiang, western Inner Mongolia, and western Gansu Province as high as 3,200 m. Areas that had previous epidemics of VL caused by *Le. donovani* still have a high risk of transmission, since *P. chinensis*, an endophilic and anthropophilic sand fly, is widely distributed over most of northwest China. Endemic areas of VL appear in Figure 9.

Transmission Cycles. In urban areas humans may serve as reservoirs of *Le. tropica*. In rural areas, nonhuman hosts of *Le. tropica* may include wild and domestic rodents living in close

FIG. 9. DISTRIBUTION OF VISCERAL LEISHMANIASIS IN EAST ASIA (DARK SHADING).

proximity to humans. Sand fly vectors inhabit the burrows of domestic and wild rodents, moles, hedgehogs and jerboas, and acquire infections while feeding on these reservoir hosts. Amastigotes (the mammalian form of the *Leishmania* parasite) ingested with the bloodmeal transform to flagellated promastigotes within the gut of the female fly. In addition to a bloodmeal, the female consumes sugar in the nectar of nearby plants. These sugars help maintain *Leishmania* infections in the flies. Promastigotes multiply within the bloodmeal in the gut of the sand fly and undergo development to infective metacyclic promastigotes. By the time the bloodmeal is digested and the fly is ready to lay its eggs, infective metacyclic promastigotes are ready to be transmitted to the next vertebrate host when the sand fly feeds again (Figure 10).

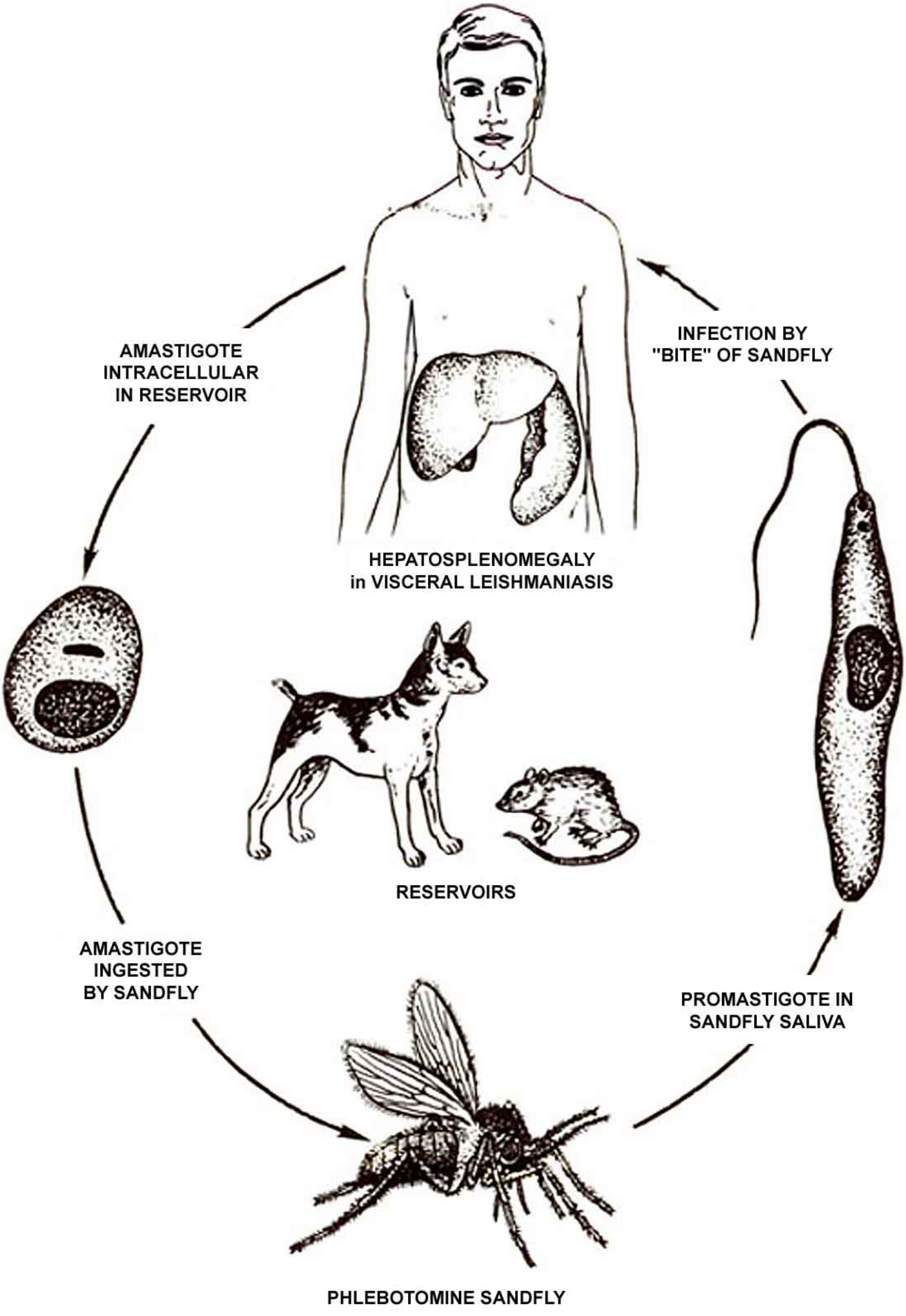
In human hosts, infective-stage promastigotes (metacyclics) are engulfed by white blood cells or macrophages, in which they transform to amastigotes. Amastigotes proliferate in the macrophage until it ruptures and new macrophages are invaded. At the skin surface, the tiny bite site becomes a small red papule that enlarges and ulcerates, with a raised edge of red inflamed skin. This inflamed area is where macrophages continue to engulf parasites, resulting in additional parasite multiplication. The ulcerated sores may become painful, last for months and, in uncomplicated CL caused by *Le. tropica*, eventually heal to form the characteristic scars seen on large numbers of people in some endemic areas of East Asia.

The suspected vectors of *Le. tropica* in East Asia are *P. chinensis* and possibly *P. mongolensis.* They occur over a very wide strip from northwestern to eastern China and across the center and southern half of Mongolia. This form of CL ("dry" sore) is most common in densely populated urban centers and is considered to have a human-sand fly-human (anthroponotic cutaneous leishmaniasis, ACL) transmission cycle, with no recognized sylvatic reservoir. In the mountainous foci, the disease is thought to have a zoonotic transmission cycle in which *P. mongolensis* maintains the parasite within a wild rodent reservoir population; however, a sylvatic reservoir has not been confirmed. Although *P. mongolensis* prefers rodents, it will bite humans.

The incriminated vectors of *Le. major* (zoonotic cutaneous leishmaniasis, ZCL) in East Asia are *P. alexandri*, *P. andrejievi*, *P. caucasicus* and possibly *P. chinensis*. In small villages and remote unpopulated areas, people who sleep outside with little clothing during warm weather often receive many sand fly bites. Sand fly species suspected of circulating the parasite among rodent reservoirs are *P. smirnovi* and *P. mongolensis*, and these species have been known to bite man.

The cycle of development of parasites causing VL is essentially the same as described for CL. The differences when dealing with VL caused by *Le. donovani* or *Le. infantum* are the species of sand fly vectoring the disease, mainly *P. alexandrei*, *P. caucasicus*, *P. chinensis*, *P. longiductus*, *P. mongolensis*, *P. sichuanensis* and *P. smirnovi*, and the disease reservoirs. In East Asia, VL is caused by infection with *Le. donovani* or *Le. infantum* and is respectively an anthroponotic

FIGURE 10. LIFE CYCLE OF *LEISHMANIA*



disease spread by sand flies from man to man and a zoonotic disease spread from animals to man. Incidental infections occur in dogs but are less common where most dogs are raised for food in fly-proof cages and where dogs are not kept as pets in close association with their owners. Wild canines such as the raccoon dog, *Nyctereutes procyanoides*, may also act as reservoirs.

Vector Ecology Profiles.

All vectors of leishmaniasis in the Old World belong to the sand fly genus *Phlebotomus*. The incriminated vector of *Le. tropica* (ACL) in East Asia is *P. chinensis*. The proven vector of *Le. donovani* (VL) is *P. alexandrei*. Suspected vectors of *Le. donovani* (VL) are *P. caucasicus* and *P. mongolensis*. The proven vectors of *Le. infantum* (VL) are *P. chinensis* and *P. sichuanensis*. Suspected vectors of *Le. infantum* (VL) in East Asia are *P. longiductus* and *P. smirnovi*. The incriminated vectors of *Le. major* (ZCL) are *P. alexandrei*, *P. andrejievi*, *P. caucasicus*, *P. chinensis* and *P. mongolensis*.

Adult sand flies rest during the daytime in dark, humid, protected areas, such as rodent burrows, rock crevices and caves. The preparation of military bunkered ground positions in desert areas provides additional protected daytime resting sites for phlebotomine sand flies. In urban areas, sand fly adults often rest in dark, cool, humid parts of homes and animal shelters. Abandoned structures and their vegetative overgrowth often become attractive wild or domestic rodent habitats and foci of rural CL.

Nectar is important as a sugar source for both male and female sand flies, and sugars are required for development of parasite infections. After a bloodmeal, eggs are deposited in dark, humid, secluded areas. The adult female has been observed to spread eggs around rather than oviposit in a single site. In military fortifications, eggs may be deposited in the cracks between stacked sandbags. Eggs hatch in 1 to 2 weeks, and the minute caterpillar-like larvae feed on mold spores and organic debris. The larvae go through 4 instars and then pupate near the larval habitat. There is no cocoon; rather, the pupa is loosely attached to the substrate by the cast skin of the fourth larval instar. Development from egg to adult requires 30 to 45 days, depending on feeding conditions and environmental temperatures. Fourth-instar larvae may diapause for weeks or months if environmental conditions are excessively cold or dry. Phlebotomine sand fly eggs, larvae and pupae have seldom been found in nature, although exhaustive studies and searches have been made. The larvae are widely distributed in the environment but are probably below the ground surface in termite mounds, rodent burrows, caves, or cracks and crevices in the soil where temperature, humidity and mold growth provide ideal conditions for larval development.

The dusk-to-dawn movement of adults is characterized by short, hopping flights just above the ground surface to avoid wind. Adult sand flies are weak fliers and generally do not travel great distances. Most flights are believed to be less than 100 m, although unengorged females

occasionally disperse as far as 1.5 km. Sand fly habitats in the region range in altitude from desert areas below sea level to 3,500 m in the mountains. In temperate climates, adult sand flies are most abundant and active in the warmer months of April through October, especially after rains. However, species of sand flies such as *P. chinensis* are found in the mountainous (up to 3,500 m) parts of northern China and Mongolia where they will bite man in cool conditions.

Female sand flies are quiet "stealth biters," and their bites may go unnoticed by military personnel. On humans, sand flies feed on exposed skin around the head, neck, legs, and arms. Female sand flies will crawl under the edges of clothing to bite skin where repellent has not been applied. Persons newly exposed to the bites of sand flies often experience a severe urticarial reaction until they become desensitized. Sand flies feed outdoors or indoors and readily penetrate the mesh of ordinary household screening or bednets. Bednets with a mesh size small enough to prevent passage of sand flies may restrict air flow and be uncomfortable for sleep in tropical climates. Sand flies may also bite during the daytime if disturbed in their secluded resting sites. Areas with some vegetation and cliffs, rock outcroppings, or other geologic formations that allow for suitable hiding places and daytime resting sites are important habitats. Exact information on reservoirs and vectors will require more extensive study in many countries of the region. Vast areas of these countries remain unsurveyed for sand fly vectors and disease. When searches are made, sand fly vectors are often found in areas where they were previously unknown.

Vector Surveillance and Suppression. Because sand flies are small and retiring, specialized methods are required to collect them. The simplest method is active searching of daytime resting sites with an aspirator and flashlight, but this method is very labor intensive. Human-landing collections are an important method of determining which species are anthropophilic. Sticky traps (paper coated with a sticky substance or impregnated with an oil such as castor oil, mineral oil or olive oil) are used to randomly capture sand flies moving to or from resting places. Traps can also be placed at the entrances of animal burrows, caves and crevices, in building debris, and in local vegetation where sand flies are likely to rest during daytime hours. A variety of light traps have been used to collect phlebotomines, but their effectiveness varies according to the species being studied and the habitat. Light traps are usually inefficient in open desert. Light traps used for mosquito collection should be modified with fine mesh netting to hold collected sand flies. Traps using animals as bait also have been devised. Collection of larvae is extremely labor intensive and usually unsuccessful because specific breeding sites are unknown or hard to find and because females deposit eggs singly over a wide area. Emergence traps are useful for locating breeding sites. Identification of sand flies requires a microscope and some training; however, with a little experience, sorting and identification by color and size will suffice using minimal magnification. For accurate species identification, laboratory microscopes with 100x magnification are required.

Because of their flight and resting behavior, sand flies that feed indoors are very susceptible to control by residual insecticides. When sand flies are exophilic or bite away from human habitations, control with insecticides is impractical, although the application of residual insecticides to a distance of 100 m around encampment sites may be helpful. Some success in reducing vector populations has been achieved by controlling the rodent reservoir or host population. Selection of encampment sites without vegetation or rock outcroppings that harbor rodents is important. Cleanup and removal of garbage and debris that encourage rodent infestation are necessary for longer periods of occupation. Pets must be strictly prohibited, because any small desert rodent and/or local dog may be infected with leishmaniasis or other diseases.

Sand flies are able to penetrate standard mesh screening used on houses and standard mesh bednets (seven threads per cm or 49 threads per sq cm). These items should be treated with permethrin to prevent entry. Fine mesh (14 threads per cm or 196 threads per sq cm) bednets can be used to exclude sand flies, but these are uncomfortable under hot, humid conditions because they restrict air circulation. The use of repellents on exposed skin and clothing is the most effective means of individual protection. Insect repellent should be applied to exposed skin and to skin at least 2 inches under the edges of the BDU to prevent sand flies from crawling under the fabric and biting. The use of **personal protective measures** (see TIM 36) is the best means of preventing sand fly-borne disease.

B. Schistosomiasis. (Bilharziasis, Snail fever)
This disease is caused by trematodes in the genus *Schistosoma* that live in the veins of humans and other vertebrates. Eggs from adult worms produce minute granulomata and scars in the organs where they lodge. Symptoms are related to the number and location of the eggs. The World Health Organization considers 5 species of schistosomes significant in terms of human disease. *Schistosoma mansoni*, *S. japonicum*, *S. mekongi* and *S. intercalatum* give rise to primarily hepatic and intestinal symptoms. Infection with *S. haematobium* usually produces urinary manifestations. The most severe pathological effects are the complications that result from chronic infection. Depending on the parasite species, symptoms of acute disease appear 2 to 8 weeks after initial infection and can be intense, especially in nonimmune hosts. Clinical manifestations include fever, headache, diarrhea, nausea and vomiting. Blood is usually present in the urine of well-established *S. haematobium* cases. The acute stage of schistosomiasis is usually more severe in the Asian forms *S. japonicum* and *S. mekongi* than in *S. mansoni*, *S. intercalatum,* or *S. haematobium*.

Military Impact and Historical Perspective. The first documented cases of schistosomiasis in U.S. military personnel occurred in 1913 among sailors assigned to the Yangtze Patrol in China. Significant portions of the crews on some patrol boats were incapacitated. During World War I, American forces were not deployed in areas endemic for schistosomiasis. However, infection was prevalent among Allied forces engaged in Mesopotamia and various parts of Africa. During

World War II, the U.S. Army hospitalized 2,088 patients with schistosomiasis. More importantly, an average of 159 days were lost per admission, almost half a year per case. Over 1,500 cases of acute infection due to *S. japonicum* were reported in U.S. troops during the reinvasion of Leyte in the Philippines. Allied and Axis troops deployed in the North African and Middle East campaigns experienced high rates of infection. During the early 1950s, Chinese troops training along the Yangtze River for an amphibious landing on Taiwan contracted 30,000 to 50,000 cases of acute schistosomiasis. As a result, 10 to 15% of the invasion force became ill, and the invasion had to be canceled. By the time the Chinese army recovered, the U.S. had established the Taiwan Defense Command and had begun routine patrols of the Taiwan Strait. Schistosomiasis due to *S. mekongi* was rare among U.S. military personnel during the Vietnam War.

Disease Distribution. Over 200 million persons are infected with schistosomiasis worldwide, causing serious acute and chronic morbidity. In East Asia, schistosomiasis is highly endemic only in China, where the *S. japonicum* complex is widespread in areas south of 35° N latitude, including the provinces of Anhui, Hubei, Hunan, Jiangsu, Jiangxi, Sichuan, Yunnan, and Zhejiang (Figure 11). Aggressive programs to control schistosomiasis were a cornerstone of Chairman Mao Zedung's patriotic health campaigns in China. As a result, the number of schistosome-infected persons was reduced from 10 million in 1955 to 1.52 million in 1989. Of 372 counties formerly endemic for schistosomiasis, transmission had been interrupted in 125 counties and was under effective control in 141 counties. Although fewer than 1 million people are currently infected, schistosomiasis remains a major public health threat in China. Over 100 million persons are at risk of infection in these schistosomiasis-endemic areas. Only *S. japonicum* has been described, although identification of unique Chinese strains based on molecular genetic data suggests emergence of new members of this species complex. The major endemic foci are in the marsh and lake regions of southern China and the Yangtze River Basin (Hubei, Hunan, Jiangxi, and Anhui Provinces), which account for 86% of the cases.

The Three Gorges Super Dam was begun in 1994 and is scheduled to be completed by the year 2009. This enormous dam will rise to a height of 180 m on the Yangtze River and will create a reservoir area of 50,700 sq. km that will submerge more than 220 counties extending from Yichang County, Hubei Province, in the east to Jiangjin and Hechuan Counties, Sichuan Province, in the west. The reservoir will displace an estimated 1.4 million people. The environmental changes created by the dam will dramatically affect *Oncomelania* snail populations and schistosomiasis transmission. After the dam is completed, the perennial high water level in the reservoir will elevate the groundwater level and contribute to the spread of vector snails. One site of particular concern is the Jianghan Plain, Hubei Province. Alluvial land and beaches will appear near many of the Yangtze River tributaries and provide conditions suitable for snail breeding. Dongting Lake, located in Hunan County, is the second largest freshwater lake in China and plays an important role in regulating the amount of water in the Yangtze River. Historically it has been a highly endemic area for schistosomiasis. Sand and silt

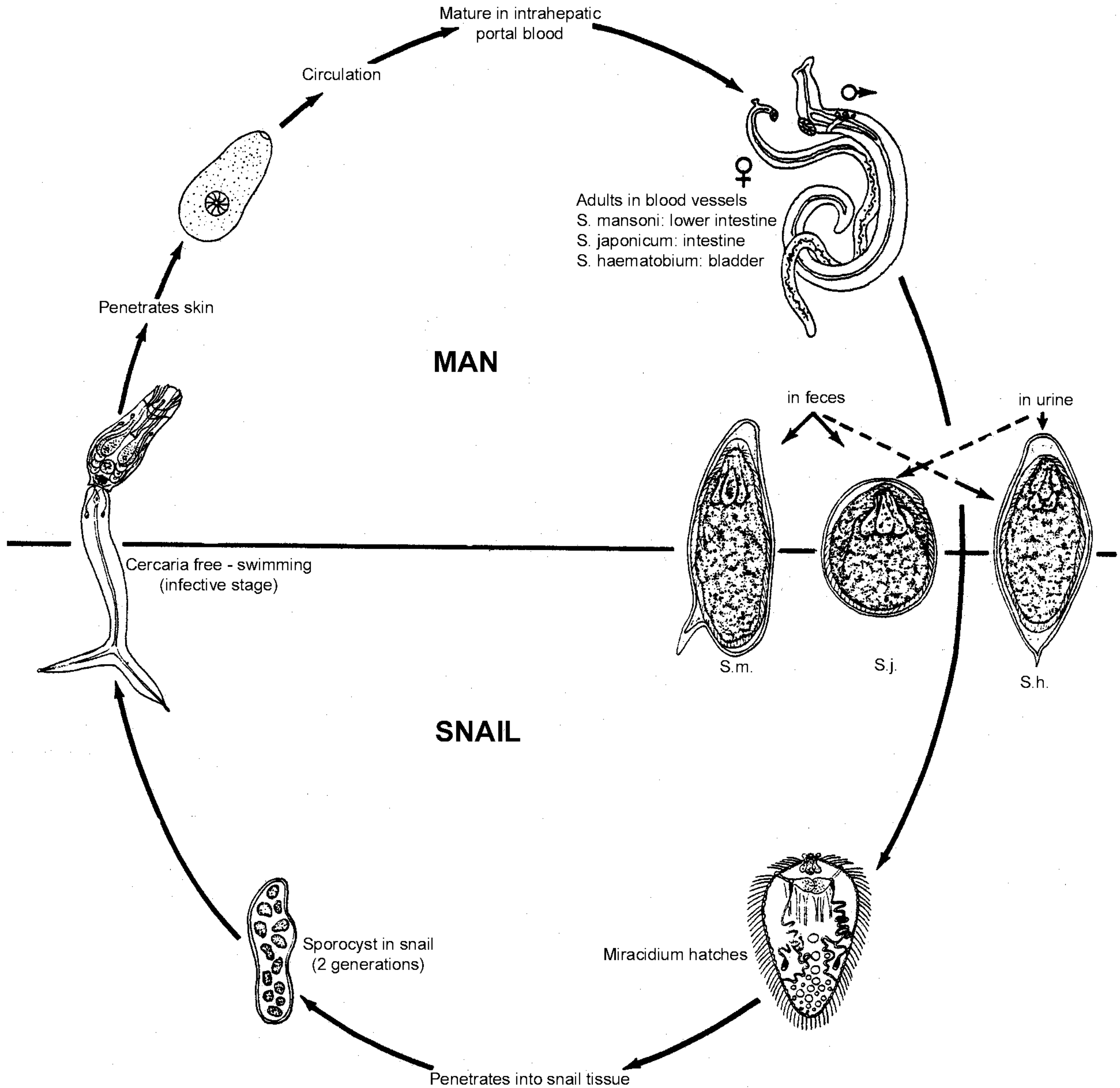
FIG. 11. DISTRIBUTION OF SCHISTOSOMIASIS IN EAST ASIA (DARK SHADING).

deposits and vegetation near the beach areas of Dongting and Boyang Lakes will be altered in ways that may increase vector snail breeding. Lateral canals from the reservoir will permit easy distribution of *Oncomelania* snails around gorges from Sichuan to Hubei and downstream. The Chinese Academy of Sciences and the Water Conservancy Committee of the Yangtze River have developed detailed plans to monitor the effects of these environmental changes on the potential spread of schistosomiasis.

There are several species of animal schistosomes circulating among animal reservoirs in East Asia. Although these cannot cause disease in humans, exposure to their cercariae can produce a temporary, and sometimes severe, dermatitis. Ricefield dermatitis is an occupational health problem in this region. Rash and itching sensations occur within hours of exposure.

Transmission Cycle(s). The life cycles of the various schistosomes infecting man are similar. A generalized life cycle appears in Figure 12. Humans are infected when they are exposed to cercariae in infested fresh water. A single infected snail intermediate host may release 500 to 2,000 cercariae daily. Cercariae are infective for about 12 to 24 hours after being released from the snail. After cercariae penetrate the skin and enter the blood or lymph vessels, they are carried to blood vessels of the lungs before migrating to the liver, where they develop into mature adult male and female worms. They mate in the liver and migrate as pairs to veins of the abdominal cavity, usually the superior mesenteric veins in the case of intestinal forms (*S. mansoni*, *S. mekongi*, *S. intercalatum* and *S. japonicum*) or the venous plexus of the urinary bladder in the case of *S. haematobium*. Four to 6 weeks after initial penetration of the skin, adult females begin laying eggs. Female worms can deposit from 300 to 2,500 eggs per day. Adult worms live 3 to 7 years, but life spans of 30 years have been reported. Only about 50% of the eggs produced reach the bladder or intestine, where they are excreted in the urine and feces. The rest become lodged in the liver and other organs. The immunological reaction to the eggs is the primary cause of both acute and chronic clinical symptoms. The degree of chronic disease is directly related to the number of eggs deposited in the tissues. After excretion in urine or feces, a schistosome egg hatches in fresh water, releasing a single miracidium that infects an appropriate species of snail. The miracidium can survive as an infective free-living entity for less than a day, but infectivity declines rapidly within 4 to 6 hours. Miracidia undergo a complicated, asexual cycle of development and multiplication in the snail, but after 30 to 60 days each successful miracidium gives rise to several hundred infective cercariae. Transmission of *S. haematobium* is essentially a man-snail-man cycle, with reservoir hosts playing an insignificant role in the maintenance of the disease. *Schistosoma mansoni* is mainly a man-snail-man cycle in Africa and southwest Asia. In the West Indies, other mammals, particularly rodents, can contribute to transmission. However, in Brazil reservoir hosts are important in the maintenance of the life cycle as well as in the spread of *S. mansoni* infection. *Schistosoma japonicum* is a true zoonosis. Numerous hosts have been found infected with this parasite, including many species

Figure 12. Life Cycle of Schistosomes



of wild and domestic animals. Over 30 species of mammals have been found naturally infected with *S. japonicum* in endemic areas of China. Cattle, water buffalo, pigs and dogs play important roles in the maintenance and transmission of *S. japonicum* in many areas of China.

Vector Ecology Profiles.

General Bionomics.

Vector snails are focally distributed in rural and urban areas, associated with slow-moving streams, irrigation canals, cisterns, and aqueducts. Snails generally increase in number as temperatures rise during warm weather. Population density is heavily dependent on rainfall, and snail habitat may temporarily increase after flooding. Expansion of the number of irrigation projects throughout China has increased the habitats for snails. Concrete-lined, covered canals are usually poor habitats, while soil-lined canals that allow reeds or other marshy vegetation to grow provide excellent snail habitats. Tidal areas are not suitable habitats for snail hosts. Snails survive dry seasons by burrowing beneath river or canal beds or under moist stones. Snails may be transported by man and sometimes by birds. Self-fertilization is common among these hermaphroditic snail species, a characteristic that enhances the dispersal of snails, since only a single founder is necessary to establish a colony. The movement of military equipment from a snail-infested area can export snails of significant medical and economic importance to other regions (Consult TIM 31 for the proper procedures to de-snail military equipment).

Specific Bionomics.

In Taiwan, the intermediate snail host of *S. japonicum* is *Oncomelania hupensis formosana*. Infection rates have ranged between 17 and 20% in endemic areas, although they are generally lower. While the snail host has occurred in 9 of Taiwan's 15 counties, the last outbreak of human infections occurred in Changhua County, west-central Taiwan. The Taiwan strain of *S. japonicum* is zoophilic and therefore does not develop to maturity in humans or produce serious disease. *Oncomelania hupensis chiui*, which also occurs on Taiwan, experimentally serves as a capable host of many strains of *S. japonicum*. However, this snail has a very focal distribution and has rarely been found naturally infected.

Oncomelania hupensis hupensis, O. nosophora, and *O. quadrasi* occur in the middle lakes region along the Yangtze River Basin. Only *O. h. hupensis* has been incriminated as a vector of human schistosomes in China. Infection rates in snails frequently range from 14 to 26%. *Oncomelania hupensis hupensis* favors ricefield irrigation ditches, fishponds, or small streams with emergent vegetation. These snails occur only in areas that are flooded 3 to 8 months a year. The snails in the Yangtze River Basin are large and coarsely ribbed. The *Oncomelania* subspecies in Yunnan and Sichuan Provinces differ from those in the middle lakes region and tend to occur in or around villages in the extensive hilly areas of these provinces, where irrigation channels or stream banks are favored habitats. These snails are small in size and finely ribbed. In the hill region, rabbits are an important zoonotic host. Snails and schistosomes occur

less often in the low coastal plains of Zhejiang and Jiangsu Provinces. The snails in this area are medium-sized and moderately ribbed. They tend to live along the margins of slow-moving streams or channels.
Oncomelania snails are amphibious and conical in shape. These snails possess gills, and the shell's aperture can be closed by means of an operculum. The death rate increases significantly after snails have been submerged for over 60 days. *Oncomelania* snails can infect passersby that contact infected snails clinging to grass or bamboo stalks. Male snails are generally smaller than females, and infection rates are generally higher in females, which shed cercariae over a longer period (33 weeks for females versus about 18 weeks for males).

In Japan, schistosomiasis caused by *S. japonicum* occurred for many years in 3 major areas (Katayama District, Kofu Basin and Chikugo River Basin) and 3 minor areas (Numazu District, Tone River Basin and Obitsu River Bank). Schistosomiasis was declared eradicated in Japan as of 1996. However, the intermediate host, *Oncomelania nosophora*, still occurs in the Kofu area and near Kurume City, northern Kyushu. Japanese *Oncomelania nosophora* lay eggs in late spring, and young snails reach 6 to 9 mm in length by October.

Biomphalaria straminea is an intermediate host of *Schistosoma mansoni* that was introduced into Hong Kong from Brazil. No schistosome parasites have been found in Hong Kong, but this species is easily infected with *S. mansoni*. *Biomphalaria straminea* requires high levels of dissolved calcium, magnesium, iron, chloride, total nitrogen, sulfates, and phosphates. In recent years, it has extended its range into the New Territories and into Guangzhou Province and may spread to other areas of China. It is frequently associated with flooded furrows or fishponds, and only rarely found in streams or rivers. *Biomphalaria* spp. are freshwater snails with a ram's horn shape. This group has a respiratory sac instead of gills, lacks an operculum, and can reach very high population densities.

Vector Surveillance and Suppression. The most important preventive measure in reducing the incidence of schistosomiasis is avoidance of fresh water with infective cercariae. Military personnel should assume that all fresh water in endemic areas is infested unless proven otherwise. The absence of snails in an area does not preclude infection, since cercariae can be transported considerable distances by water currents. Combat commanders and troops must be instructed in the risk of infection and measures for schistosomiasis prevention. No topical repellent is currently available that provides long-term protection against cercarial penetration. Experimental studies have shown the insect repellent DEET to provide a significant level of protection; however, the beneficial effects of DEET last only a few minutes because of its rapid absorption through the skin or loss from the skin surface by washing. When DEET is experimentally incorporated into liposomes (LIPODEET), its activity is prolonged for more than 48 hrs after a single application. Commercial formulations that can be used to protect against cercarial penetration may be available in the near future. Cercariae penetrate the skin rapidly, so efforts to remove cercariae after exposure by applying alcohol or other disinfectants to the skin

have limited value. Standard issue BDUs offer substantial protection against penetration, especially when trousers are tucked into boots. Rubber boots and gloves can provide additional protection for personnel whose duties require prolonged contact with water containing cercariae.

Cercarial emergence from snails is periodic, and the numbers found in natural waters vary with the time of day. Light stimulates cercarial release for *S. mansoni* and *S. haematobium*. Minimal numbers of cercariae are present early in the morning and at night. Restricting water contact during peak cercarial density may reduce risk of infection. Avoid water contact in mid to late morning, except where *S. japonicum* is endemic and in the Caribbean where *S. mansoni* is endemic. In these areas, nocturnal rodents are the primary hosts and their peak activity is in the late afternoon and early evening. Stepping on and crushing an infected snail will release thousands of cercariae.

Cercariae are killed by exposure for 30 minutes to concentrations of chlorine of 1 ppm. Treating water with iodine tablets is also effective. Heating water to 50°C for 5 minutes or allowing it to stand for 72 hours will render it free of infective cercariae. Water purification filters and reverse osmosis units are also effective in removing cercariae.

Molluscicides can be applied to extensive or limited areas by preventive medicine teams to eliminate snails from aquatic sites that are likely to be used by military personnel. Consult TIM 23, A Concise Guide for the Detection, Prevention and Control of Schistosomiasis in the Uniformed Services, and TIM 24, Contingency Pest Management Guide, for molluscicide recommendations and application techniques. There is little evidence that snail intermediate hosts have developed resistance to commonly used molluscicides like niclosamide. In China, sodium pentachlorophenate has been used for snail control for over 30 years, with the result that significant residues of this molluscicide can now be found in human blood, milk and aquatic sediments. Bromoacetamide, developed in China during the 1980s, is lethal to *Oncomelania* snails at a dosage of only 1 ppm and is nontoxic to fish at this dosage.

C. Filariasis.

Bancroftian filariasis is caused by the nematode *Wuchereria bancrofti*, which normally resides in the lymphatic system of infected humans. Eight to 12 months after infection, adult female worms release thousands of microfilariae (prelarval filarial worms) into the circulatory system. Acute reaction to infection includes swelling of lymph nodes, fever and headache, and allergic reaction to metabolic products of filariae. However, many individuals are asymptomatic in the early stages of infection. Female nematodes continue to produce microfilariae over the next 15 to 18 years. Chronic filariasis develops slowly, with recurrent episodes of fever and inflammation of the lymph glands. Microfilariae can obstruct the lymphatic system, causing the legs, breasts or scrotum to swell to grotesque proportions, a chronic condition known as elephantiasis. This occurs only after repeated infections. Nearly half of all infected people are clinically asymptomatic, although they have microfilariae circulating in their blood and have

hidden damage to their lymphatic and/or renal systems. The death of numerous microfilariae resulting from drug therapy may cause severe immune reactions.

Brugian filariasis is caused by the nematodes *Brugia malayi* and *B. timori*. Clinical manifestations are similar to those of Bancroftian filariasis, except that the recurrent acute attacks of filarial fever and inflammation of the lymph glands are more severe, and elephantiasis is usually confined to the legs below the knees.

Military Impact and Historical Perspective. Microfilariae of *W. bancrofti* were first discovered in the blood of a patient in Brazil in 1878. This was the first discovery of a pathogen transmitted by insects. Over 70 million people worldwide are estimated to be infected with *W. bancrofti*, resulting in serious economic costs to developing countries. The long incubation period and requirement for repeated infections before chronic clinical symptoms appear render Bancroftian filariasis of little medical significance to military operations. However, military personnel moving into an endemic area from one that is free from filariasis may develop acute symptoms such as swelling of the lymph glands, headache and fever months before larvae become mature. From 1942 to 1944, American military forces in the Samoan-Ellice-Wallis Islands rapidly developed swollen lymph glands and swollen extremities following repeated exposure to infected mosquitoes. Acute filariasis is the primary military concern, because its symptoms develop fairly rapidly and may be severe enough to cause removal of troops from their duties. Clinical manifestations of filariasis often occur with no demonstrable circulating microfilariae (occult filariasis). Of several thousand cases involving American military personnel during World War II, microfilariae were found in only 10 to 15 patients. In addition, the sight of people with grotesque deformities caused by chronic infection can have an adverse psychological impact. Medical personnel should be aware that troops with brief exposure to infection are often not diagnosed until after they return from deployments.

Disease Distribution. *Wuchereria bancrofti* occurs in most tropical and some subtropical regions, including Latin America, Africa, Asia and the Pacific islands. Mass migrations of infected humans are usually required in order to introduce the disease to new areas. The nocturnally periodic form of *B. malayi* occurs in rural populations living in open rice-growing areas or near open swampy areas in Asia, from India to Japan. The subperiodic form of *B. malayi* is associated with swampy forests of Malaysia, Indonesia and the Philippines. Infections with *B. timori* occur on Timor and other southeastern islands of Indonesia.

It is estimated that 1 billion people are at risk of acquiring infection. Over 120 million people in at least 80 countries are currently infected with some form of filariasis, and 40 million of these are seriously incapacitated and disfigured by the disease. At least one-third of the people infected with the disease live in India. Ninety percent of infections worldwide are caused by *W. bancrofti*, and most of the remainder by *B. malayi*.

In China, extensive control programs started in the 1950s have greatly reduced the prevalence of filariasis. By 1994, filariasis was under effective control in all endemic areas of the country. Nocturnally periodic forms of *B. malayi* and *W. bancrofti* are currently endemic at low levels in southern and eastern China. There is a low risk of *B. malayi* transmission in the southern coastal provinces of South Korea, especially Cheju-do Island. Filariasis was last reported in Japan from the Ryukyu Archipelago and the Izu Schichto Islands but has probably been eradicated. Likewise, the last reports of Bancroftian filariasis in Taiwan were from the Pescadores, Kinmen (Quemoy), and Matsu islands, but transmission probably no longer occurs. The distribution of filariasis in East Asia is depicted in Figure 13.

Transmission Cycle(s). Microfilariae circulating in human blood are ingested by mosquitoes and undergo several days of development before the vector can transmit infective stages of the nematode. Infective parasites enter the bloodstream directly during a mosquito bite. A few nematode larvae are deposited on the skin and can enter the host through skin abrasions. In humans, larvae undergo development to adults that produce microfilariae for many years. Over most of the geographic range of this disease, including East Asia, *W. bancrofti* microfilariae exhibit pronounced nocturnal periodicity and consequently are ingested by night-biting mosquitoes. Peak abundance of microfilariae in the blood occurs between 2300 and 0300 hours. *Culex pipiens quinquefasciatus* is the most common urban vector. In rural areas, transmission is mainly by *Anopheles* spp. and *Culex* spp. There are no known animal reservoirs of Bancroftian filariasis.

There are no significant animal reservoirs for nocturnally periodic forms of *B. malayi* or *B. timori*. The subperiodic form of *B. malayi* infects humans and monkeys, especially leaf monkeys *(Presbytis* spp.), wild and domestic cats, and pangolins (scaly anteaters). The zoonotic and epidemic life cycles of subperiodic *B. malayi* usually do not overlap.

Vector Ecology Profiles.

Vectors of filariasis are widespread in the region. In Brugian filariasis, *Mansonia* spp. serve as the major vectors on the Indian subcontinent but are not important vectors in East Asia. *Anopheles sinensis*, *An. lesteri anthropophagus* and *Aedes togoi* are the primary vectors in this region. *Anopheles sinensis* prefers to feed on cattle and feeds primarily outdoors. However, populations of this mosquito may be extremely high in rice-growing areas. *Anopheles lesteri anthropophagus* is a more efficient vector of *B. malayi* because it is strongly anthropophilic, readily enters houses, and has a peak biting time when microfilariae are more abundant in the blood. Other species of *Anopheles*, such has *An. yatsushiroensis* and *An. kwieyangensis*, occasionally transmit *B. malayi* in some parts of China but are insignificant vectors. *Culex pipiens pallens* has been recorded as a secondary vector of *B. malayi* on some offshore Japanese islands.

FIG. 13. DISTRIBUTION OF FILARIASIS IN EAST ASIA (DARK SHADING).

Aedes togoi is widely distributed in rocky coastal areas of China, Japan, the Korean Peninsula and Taiwan, and is the primary vector on Cheju-do Island. It breeds primarily in rock holes and rocky depressions containing fresh or brackish water; however, larvae may also be found in earthenware jars and cisterns. Development of larvae is retarded when salt concentrations are greater than 10 g of sea salt per liter. Oviposition of females decreases when NaCl concentrations exceed 20 g per liter. *Aedes togoi* is a very strong flier capable of dispersing between islands. However, females normally restrict their egg-laying and host-seeking activity to rocky terrain between the high tide mark and coastal vegetation. A high percentage of females are autogenous and are capable of laying up to 100 eggs without a bloodmeal if larval stages have been well nourished. Populations increase after rainfall or monsoon seasons. *Aedes togoi* is highly anthropophilic and readily enters houses to feed. It will bite throughout the day, but feeding activity is much more intense at night, frequently peaking between 0100 and 0300 hours. In cold climates it may diapause in the egg or larval stage. A photoperiod of 10 hours of light and temperatures of 16°C or lower will initiate larval diapause.

Members of the *Culex pipiens* complex, particularly *Culex pipiens quinquefasciatus* and *Cx. p. pallens*, are the primary vectors of *Wuchereria bancrofti* because they are highly anthropophilic, and their peak feeding activity, from 2200 to 0300 hours, coincides with the nocturnal periodicity of microfilariae in human blood. The complex is widespread and abundant throughout East Asia as a result of rapid urbanization and inadequate disposal of wastewater. Adults usually prefer to feed on birds but readily feed on humans and large animals like cattle and goats. They begin feeding early in the evening, usually within 2 hours of sunset, and feed throughout the night. Adults are strong fliers and will travel 3 to 5 km from breeding sites to find a bloodmeal. *Culex pipiens quinquefasciatus* feeds and rests indoors or outdoors. This species is an annoying biter and produces a high-pitched buzzing sound that can easily be heard. Before and after feeding indoors, females rest behind or under furniture and draperies, or in closets. Adults are more endophilic in cool weather during the fall. Three or 4 days after a bloodmeal, *Cx. p. quinquefasciatus* deposits egg rafts containing 75 to 200 eggs on the water surface. Common oviposition sites include cisterns, water troughs, irrigation spillovers, wastewater lagoons, and swamps. Eggs hatch 2 to 4 days after deposition. Larvae of *Cx. p. quinquefasciatus* generally prefer ground pools with high concentrations of organic matter or swamps with emergent vegetation. Polluted water from septic systems is ideal for larvae of this species. Slums with poor sanitation and urban construction sites have proliferated in many areas and provide abundant breeding sites for the *Culex pipiens* complex. Larval development requires 7 to 9 days at a temperature range of 25 to 30 C. At lower temperatures, larval stages may require 15 to 20 days. The pupal stage lasts about 2 days. Members of the complex overwinter as adults in temperate climates, but adults may be found year-round in southern parts of the region or where sewage effluent keeps breeding sites warm.

Vector Surveillance and Suppression. Light traps are used to collect night-biting mosquitoes, but not all mosquito species are attracted to light. The addition of the attractant carbon dioxide

to light traps increases the number of species collected, especially *Anopheles*. *Aedes togoi* is not readily attracted to light, and carbon dioxide is not an effective attractant for this species. Traps using animals, or even humans, as bait are useful for determining feeding preferences of mosquitoes collected. Adults are often collected from indoor and outdoor resting sites using a mechanical aspirator and flashlight. Systematic larval sampling with a long-handled white dipper provides information on species composition and population dynamics, which is used when planning control measures.

Mosquitoes can be individually dissected and examined for filarial infection. Large numbers of mosquitoes can be processed more quickly by crushing them in a saline solution and removing filarial worms with a sieve. The parasites can then be concentrated by centrifugation. Careful identification is required so as not to confuse medically important species of filarial worms with those that chiefly infect nonhuman hosts.

Application of residual insecticides to the interior walls of buildings and sleeping quarters is an effective method of interrupting filarial transmission when local vectors feed and rest indoors. Nightly dispersal of ultra low volume (ULV) aerosols can reduce exophilic mosquito populations. Larvicides and biological control with larvivorous fish can reduce larval populations before adults have an opportunity to emerge and disperse. However, it is necessary to maintain vector density at low levels for prolonged periods to control filariasis. Hence chemotherapy of infected persons to eliminate microfilariae from the blood has been the chief tool to control the disease in endemic areas. Studies in China have demonstrated that the incidence of filariasis declines and may disappear within 3 to 5 years when the number of infected humans circulating microfilariae falls below 1% of the population. Insecticides labeled for mosquito control are listed in TIM 24, Contingency Pest Management Guide. Chemical control may be difficult to achieve in some areas. After decades of insecticide use, many species of the *Cx. pipiens* complex are now resistant to insecticides (Appendix B. Pesticide Resistance in East Asia). Sanitary improvements, such as filling and draining areas of impounded water to eliminate breeding habitats, should be used to the extent possible. Placing nontoxic expanded polystyrene beads (2 to 3 mm in diameter) into pit latrines and cess pits to completely cover the water surface with a 2 to 3 cm thick layer prevents *Culex* spp. from laying eggs in such places. A single application can persist for several years and give excellent control. *Mansonia* mosquitoes are usually controlled by removing or killing the aquatic weeds upon which the larvae and pupae depend for their oxygen requirements. If insecticides are used to control *Mansonia* larvae, granules or pellets are more suitable than liquid formulations because they can penetrate the vegetation layer and sink to the bottom of breeding places to release chemicals toxic to the larvae.

The proper use of repellents and other **personal protective measures** is thoroughly discussed in TIM 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance. The use of bednets impregnated with a synthetic pyrethroid, preferably

permethrin, is an extremely effective method of protecting sleeping individuals from mosquito bites. The interior walls of tents can also be treated with permethrin. Buildings and sleeping quarters should be screened to prevent entry of mosquitoes and other blood-sucking insects.

C. Lyme Disease. (Lyme borreliosis, tick-borne meningopolyneuritis, erythema chronicum migrans, Lyme arthritis, Barnwart's syndrome)
The causative agent of Lyme disease is the spirochete bacterium *Borrelia burgdorferi* sensu strictu. Different genospecies of the Lyme disease spirochete are responsible for human disease in different regions of the world. Like syphilis, the clinical disease manifests itself in acute and chronic stages. Initially there is a highly characteristic expanding skin lesion (erythema migrans) that develops in about 60% of cases. Flu-like symptoms usually occur about the same time. Weeks to months after initial infection, cardiac, neurological or arthritic symptoms and other joint abnormalities may occur and persist for years. Different genotypes have been associated with characteristic clinical symptoms. *Borrelia afzelii* prevails in skin lesions, whereas *B. garinii* is associated with neurological involvement. Treatment in the late stages of Lyme disease can be difficult, and chronic infection can be very debilitating. Early recognition and treatment are critical.

Military Impact and Historical Perspective. Lyme disease is an emerging infection of public health importance in many parts of the world. Since its recognition in Connecticut during the 1970s, Lyme disease has been reported from 48 states. The development of effective vaccines, absence of antibiotic resistance in *Borrelia burgdorferi* spirochetes, and availability of highly effective repellents should minimize the military impact of Lyme disease. Since 1995, about 100 cases of Lyme disease have been officially reported in U.S. Army personnel worldwide.

Disease Distribution. Lyme disease is the most common tick-borne infection of humans in the temperate Northern Hemisphere, including North America, Europe and northern Asia. Lyme-like syndromes have been reported from South America, Africa, tropical Asia and Australia, but their epidemiology has not been clarified in these regions. It is difficult to compare published results from different labs using different diagnostic tests. Incidence of antibodies to *B. burgdorferi* is correlated with exposure to tick habitat. Forestry workers, people engaged in animal husbandry, recreational hikers and campers, and people with other lifestyles or occupations that increase exposure to vector ticks have a higher incidence of antibodies to Lyme disease spirochetes in endemic areas. Up to 20% of forestry workers in Saitama Prefecture, Japan, were seropositive in a survey conducted in 1994.

Most research on Lyme disease in East Asia has been conducted in the last decade, and the epidemiological picture of the disease in the region is incomplete and confusing. Sporadic human cases of Lyme disease have occurred throughout Japan caused by *B. afzelii*, *B. garinii* and a new species of *Borrelia* isolated from *Ixodes ovatus* and named *B. japonica*. The Japanese strains of *B. afzelii* and *B. garinii* have unique molecular characteristics that distinguish them

from European and Russian strains of these agents. Several new species of Lyme *Borrelia* have been isolated in Japan, but their role in human disease is not known. These include *B. tanukii* and *B. turdae* isolated from the ixodid ticks *Ixodes tanuki* and *I. turdus*, respectively, and a new species named *B. miyamotoi* isolated from *I. persulcatus*.

From 1987 to 1996, a Lyme disease survey was conducted in 60 counties and districts of 22 provinces in China. Endemic foci were discovered in 17 provinces, and typical cases of Lyme disease were diagnosed in 11 provinces. Strains of *B. afzelii* and *B. garinii* were isolated from ticks and small mammals, and these strains seemed more closely related genetically to Japanese strains than to strains from Europe. Numerous isolations were made in northeastern China and Inner Mongolia. Based on these studies, Lyme disease is undoubtedly enzootic in Mongolia.

Several species of Lyme *Borrelia* have been isolated from ticks and small rodents in South Korea, including *B. afzelii*, *B. garinii* (both isolated from *I. persulcatus*), *B. valaisiana* (isolated from *I. nipponensis*), and a recently identified but unnamed strain isolated from *I. granulatus* and *Apodemus agrarius* mice collected in Haenam. However, only 3 human cases had been confirmed as of 1999. Based on South Korean studies, Lyme disease is probably enzootic in North Korea as well.

Spirochetes were isolated from 6 species of wild and peridomestic rodents in Taiwan during the mid 1990s. The highest infection rates were found in the brown country rat, *Rattus losea*. Serological and PCR analysis indicated that all of these isolates were genetically related to *B. burgdorferi* sensu strictu. This was the first evidence of Lyme disease in Taiwan. The first human case of Lyme disease was reported in 1998.

Transmission Cycle(s). All known primary vectors of Lyme disease are hard ticks of the genus *Ixodes*, subgenus *Ixodes*. Infective spirochetes are transmitted by tick bite. Nymphal ticks usually transmit the disease to humans. Transmission of the pathogen often does not occur until the tick has been attached for at least 24 hours, so early tick detection and removal can prevent infection. *Borrelia burgdorferi* has been detected in mosquitoes, deer flies and horse flies in the northeastern United States, Europe and Japan, but the role of these insects in Lyme disease transmission appears to be minimal. Rodents, insectivores and other small mammals maintain spirochetes in their tissues and blood and infect larval ticks that feed on them. Infection with more than one genotype has been found in ticks as well as vertebrate reservoirs. Spirochetes can be passed transstadially but are seldom passed transovarially by female ticks.

Small mammals vary in their relative importance as reservoir hosts in different geographic regions. Field mice in the genera *Apodemus* and *Clethrionomys* are the chief reservoirs across Eurasia. However, in East Asia, Lyme disease spirochetes have been isolated from a wide variety of small mammals. In China, isolations have been made from *Apodemus agrarius*, *A. peninsulae, A. speciosus*, *Crocidura dsinezumi*, *Clethrionomys rufocanus*, *Eutamias sibiricus*,

Rattus confucianus, *R. edwardsi* and *R. norvegicus*. In Japan, isolations have been made from *A. argenteus*, *A. speciosus ainu*, *C. rufocanus*, *Eothenomys andersoni*, *E. smithii*, *Microtus montebelli*, *Sorex dsinezumi*, *S. unguiculatus*, and the fox *Vulpes vulpes schrencki*. Experimental studies suggest that birds are poor hosts of Lyme disease spirochetes and play an insignificant role as reservoirs. Birds are involved in the circulation of *B. burgdorferi* principally as disseminators of infected ticks to new areas. However, *B. garinii* was isolated from the red-bellied thrush, *Turdus chrysolaus*, in Japan in 1996. This was the first isolation of Lyme disease spirochetes from a migratory bird in that country. Based on isolation of spirochetes from bird-feeding ticks, some Japanese investigators have suggested that birds of the genera *Emberiza* and *Turdus* may be reservoirs for *Borrelia* in Japan, and that *B. garinii* may have been introduced into Japan by migratory birds from northeastern China via Korea. High levels of antibody to Lyme spirochetes have been found in Japanese serows, *Capricornis crispus*, in the central mountainous areas of Japan.

Large mammals, especially deer, are important as hosts of adult ticks and essential to completion of the life cycle of the vector, but are unimportant as reservoirs of the pathogen. Adults and nymphs of the primary vectors in Japan parasitize the sika deer, *Cervus nippon yesoensis*. A high incidence of antibodies to Lyme disease spirochetes has been found in domestic animals such as cattle, sheep and dogs in Japan and China.

Vector Ecology Profiles.

Lyme disease spirochetes have been isolated from many species of ticks in East Asia. The role each species plays in the epidemiology of Lyme disease in the region awaits further research. Most are probably zoonotic vectors; only a few are important in the transmission of Lyme disease to humans. It is clear that the Taiga tick, *I. persulcatus*, is the principal vector throughout the region. It is widespread and abundant in many parts of East Asia and is a common source of tick bites in humans. The majority of *Borrelia* isolations have come from this species. Its biology is discussed in the section on tick-borne encephalitis. *Ixodes ovatus* is an important vector in Japan. Infection rates for both species can be very high. The infection rates for adults of *I. persulcatus* and *I. ovatus* collected in Nagano Prefecture in the early 1990s were 21% and 25%, respectively. Forty-three percent of adult *I. persulcatus* were infected during a 1986 survey in Hailin County, Heilongjiang Province, China. *Borrelia* spirochetes have also been isolated from the following tick species in Japan: *Haemaphysalis flava*, *I. columnae*, *I. tanuki* and *I. turdus*.

From 1987 to 1997, a total of 17,000 ticks were collected from 20 provinces of China. *Ixodes persulcatus* accounted for 80% of the ticks collected. Based on tick abundance and infection rates, it was concluded that *I. persulcatus* is the principal vector in northern China, and *Haemaphysalis bispinosa* and *I. granulatus* are important vectors in southern China. Other studies have indicated that *H. longicornis* and *H. concinna* are significant vectors. The bionomics of *H. concinna* are discussed under tick-borne encephalitis. Isolations of Lyme

disease spirochetes have also been made from the following tick species in China: *Dermacentor silvarum, H. cornigera taiwana*, *H. japonicum*, *I. acutitarsus*, and *I. rangtangensis*.

In South Korea, Lyme disease spirochetes have been isolated from *I. granulatus* and *I. nipponensis* in addition to *I. persulcatus*.

Specific bionomics.
Haemaphysalis longicornis is unusual in that it exhibits normal sexual reproduction in most parts of East Asia but is parthenogenetic in the northern areas of China, Japan and Mongolia. Adults frequently parasitize cattle. Mating occurs on the host, and females detach after 6 to 9 days of feeding. One male can inseminate several females. Depending on the body weight of the female tick, up to 3,000 eggs are deposited after a bloodmeal. Parthenogenetic ticks produce fewer eggs.

Ixodes nipponensis occurs in montane regions, although larval stages are not very resistant to sub-zero temperatures. Larvae and nymphs parasitize small rodents and birds and often feed on reptiles. Adults parasitize cattle, horses, dogs, beavers, badgers and humans and may feed for a week or longer.

Ixodes ovatus inhabits montane to subalpine areas between 600 and 1,800 m in Japan. Adults parasitize sika deer but also attack hares and humans. Peak abundance of immature stages occurs in July and August. Adults exhibit bimodal peaks of abundance from the end of May to mid-July, and again at the end of August.

Ixodes turdus frequently feeds on birds in Japan, especially thrushes. It is very uncommon but may be a significant zoonotic vector if birds are an important reservoir of *Borrelia* spirochetes.

Ixodes granulatus feeds primarily on rodents and is an important zoonotic vector in many parts of East Asia.

Vector Surveillance and Suppression. There are several methods that can be used to determine the numbers and species of ticks in a given area. These include dragging a piece of flannel cloth over vegetation where ticks are waiting for a passing host and collecting the ticks that attach to the cloth, collecting ticks from animal hosts or their burrows/nests, attracting ticks to a trap using carbon dioxide (usually in the form of dry ice), and removing ticks from a person walking in a prescribed area. Different species and life stages of ticks are collected disproportionately by the various methods, and techniques selected must be tailored to the species and life stage desired. These collection procedures are discussed thoroughly in TIM 26, Tick-borne Diseases: Vector Surveillance and Control.

Habitat modification can reduce tick abundance in limited areas. Mechanical removal of leaf litter, underbrush, and low-growing vegetation reduces the density of small mammal hosts and deprives ixodid ticks of the structural support they need to contact hosts. Leaf litter also provides microhabitats with environmental conditions suitable for survival, such as high relative humidity. Controlled burning, where environmentally acceptable, has been shown to reduce tick populations for 6 to 12 months.

Large-scale application of pesticides to control ticks is usually impractical and may be environmentally unacceptable on military installations during peacetime. Chemical treatment should be confined to intensely used areas with a high risk of tick-borne disease. Liquid formulations of pesticides can be applied to vegetation at various heights to provide immediate reduction in tick populations. Granular formulations provide slower control and only affect ticks at ground level. Both formulations give approximately the same level of control when evaluated over a period of several weeks. Consult TIMs 24 and 26 for specific pesticide recommendations and application techniques.

Exclusion of deer and other large animals using electric or nonelectric fences has reduced populations of *Ixodes* ticks that require large animals to complete their life cycle. This technique would have limited applicability in most military situations.

The **personal protective measures** discussed in TIMs 26 and 36 are the best means of protecting individual soldiers from tick bites. Clothing impregnated with permethrin is particularly effective against crawling arthropods like ticks. Frequent body checks while operating in tick-infested habitat are essential. Tick attachment for several hours is required for transmission of many tick-borne pathogens, so early removal of ticks can prevent infection (Appendix E).

The FDA has approved LYMErix, a vaccine developed by SmithKline Beecham, for vaccination of people ages 15 to 70. The vaccine is only about 80% effective, and it takes 3 shots over a full year to build optimal immunity. It protects only against North American strains of *B. burgdorferi* and is not effective against European genotypes of the spirochete. Experimental work in Japan has shown that a whole cell vaccine prepared from North American and European isolates did not elicit protective immunity against infection with Japanese isolates. Therefore, vaccinated individuals must still use **personal protective measures** against ticks.

VII. Other Diseases of Potential Military Significance.

A. Leptospirosis. (Weil disease, Canicola fever, Hemorrhagic jaundice, Mud fever, Swineherd disease)
The spirochete bacterium *Leptospira interrogans* is the causative agent of this zoonotic disease. More than 200 serovars of *L. interrogans* have been identified, and these have been classified into at least 23 serogroups based on serological relationships. Common clinical features are fever with sudden onset, headache, and severe muscle pain. Serious complications can occur. Infection of the kidneys and renal failure is the cause of death in most fatal cases. The severity of leptospirosis varies greatly and is largely determined by the infecting strain and health of the individual. In some areas of enzootic leptospirosis, a majority of infections are mild or asymptomatic. The incubation period is 10 to 12 days after infection.

Disease Distribution. Leptospirosis is one of the most widespread zoonoses in the world. Distribution is worldwide in urban and rural areas of both developed and developing countries. Leptospirosis is regarded as focally enzootic throughout East Asia, and sporadic human cases are reported from most countries as a result of occupational exposure. The highest incidence of leptospiral antibodies is usually found in veterinarians and workers in animal husbandry. Close association of humans, animals, soil and water facilitates the spread of leptospirosis to humans. Consequently, rice paddies are a frequent source of infection. Leptospirosis is also common in flood-prone areas.

China: Leptospirosis has been recognized as a notifiable disease in China since 1955. Incidence of human disease has been steady in recent years but outbreaks have occurred, especially in several southern provinces. Leptospirosis is endemic in 26 of China’s 30 provinces. Distribution of endemic areas is primarily located between 25° to 35° N latitude and between 100° and 120° E longitude, particularly in those provinces with drainage areas along the Yangtze and Huaihe rivers. At least 70 serovars have been isolated, including 35 serovars that were isolated for the first time in China. Predominant serovars have changed over the years, and serovar lai is currently the most prevalent serovar in China and South Korea. From 1958 to 1987, 35 serotypes from 16 serogroups were isolated in Sichuan Province. Data collected from 1960 to 1997 in Yichang City of Hubei Province showed an annual average incidence of 15.4 cases of leptospirosis per 100,000 persons, with an epidemic interval of 10 years. A 1993 survey of several localities in Hainan Province indicated a high rate of exposure to *Leptospira*; leptospiral antibodies were found in 52% of the humans tested. During an environmental survey from 1988 to 1992, *Leptospira* were isolated from 2.1% of water samples and 4.9% of soil samples collected in 5 counties of Yunnan Province. These data indicate that military personnel would be at high risk of exposure to leptospirosis in many parts of East Asia.

Japan: An outbreak of leptospirosis occurred among U.S. military personnel during September 1987 on the island of Okinawa. Cases occurred in recreational swimmers as well as troops involved in military training.

Korea: Outbreaks of leptospirosis occurred in South Korea after severe flooding during 1987. Leptospirosis has significantly decreased in the human population of South Korea since 1988, following a vaccination program initiated the same year. However, infection rates with *L. interrogans* in field rodents did not decline between 1984 and 1996.

Transmission Cycle(s). *Leptospira* infect the kidneys and are transmitted in the urine of infected animals. Humans become infected through contact of abraded skin or mucous membranes with contaminated water, moist soil or vegetation. *Leptospira* survive only in fresh water. Spirochetes are not shed in the saliva; therefore, animal bites are not a source of infection. Although infected humans shed *Leptospira* in urine, person-to-person transmission is rare. Infection may occasionally occur by ingestion of food contaminated with urine from infected rats. Infection from naturally infected meat or milk is uncommon. Spirochetes disappear from whole milk within a few hours. Because of its prevalence in rodents and domestic animals, leptospirosis has usually been an occupational hazard to farmers, sewer workers, veterinarians, animal husbandry workers, slaughterhouse workers, and rice and sugarcane field workers.

Numerous wild and domestic animals act as reservoirs, including rodents, swine, cattle, sheep, goats, buffalo, camels, horses, and even elephants. In many parts of East Asia vast human populations are exposed daily to animal populations and their excreta. Cattle are a major source of leptospirosis in some parts of China. Dogs are a good indicator of the distribution of different leptospiral serovars in the environment. Cats and dogs are frequently infected and may be a source of infection to humans. A survey during the late 1980s found leptospiral antibodies in 23% of stray dogs in Okinawa. The percentages of house dogs positive for leptospiral antibodies in 1998 throughout 6 prefectures of Japan were: 26% in Hokkaido Prefecture, 40% in Shizuoka Prefecture, 9% in Toyama Prefecture, 10% in Hyogo Prefecture, 15% in Okayama Prefecture, and 29% in Okinawa Prefecture. All positive dogs were free of clinical signs of disease. In 1995, 12.5% of dogs surveyed in Hunan Province, China, were positive for leptospiral antibodies. Many small mammals are involved in the epidemiology of leptospirosis in East Asia, and the field mouse, *Apodemus agrarius*, has been implicated as a primary reservoir. This mouse inhabits grassy fields, cultivated areas, woodlands and forests. It frequently moves into human habitations in the fall and winter. The incidence of leptospirosis has increased in areas where irrigation and year-round cultivation provide food and cover to host rodents.

Disease Prevention and Control. To prevent leptospirosis, domestic rodents need to be controlled around living quarters, and food storage and preparation areas. *Leptospira* are readily killed by detergents, desiccation, acidity, and temperatures above 60°C. Good sanitation reduces

the risk of infection from commensal rodents. Troops should be educated about modes of transmission and instructed to avoid swimming or wading in potentially contaminated waters or adopting stray dogs or cats as pets. Leptospirosis could be a problem following flooding of contaminated streams or rivers. Vaccines have been used effectively to protect workers in veterinary medicine, and immunization has also been used to protect against occupational exposure to specific serovars in Japan, China, Korea, Italy, Spain, France and Israel. The *Leptospira* whole cell vaccine currently used in China is considered safe and effective, but the duration of protection conferred by this vaccine is only six months to one year. Short-term prophylaxis may be accomplished by administration of antibiotics. Doxycycline was effective in Panama in preventing leptospirosis in military personnel.

B. Hantaviral Disease. [Epidemic hemorrhagic fever, Korean hemorrhagic fever, nephropathia epidemica, hemorrhagic nephrosonephritis, hemorrhagic fever with renal syndrome (HFRS), hantavirus pulmonary syndrome (HPS)**]**
Hantaviruses are a closely related group of zoonotic viruses that infect rodents. The genus *Hantavirus*, family Bunyaviridae, comprises at least 14 viruses, including those that cause HFRS and HPS. Disease syndromes in humans vary in severity but are characterized by abrupt onset of fever, lower back pain, and varying degrees of hemorrhagic manifestations and renal or pulmonary involvement. Depending in part on which hantavirus is responsible for illness, HFRS can appear as a mild, moderate or severe disease. Severe illness is associated with Hantaan virus (HTN), and mild to moderate disease is associated with Seoul virus (SEO), primarily in Asia and the Balkans. The case fatality rate in Asia is about 5%, somewhat higher in the Balkans, and variable throughout the rest of the world. Convalescence takes weeks to months. A less severe illness caused by Puumala virus (PUU) and referred to as nephropathia epidemica predominates in Europe. Dobrava-Belgrade virus (DOB) has caused severe HFRS cases in several countries surrounding Turkey, with mortality rates of up to 20%. Tula virus (TUL) has been isolated throughout Europe to the Kirov region of Russia, but its role in human disease is unclear. HPS, caused by several hantaviruses, has been reported throughout North and South America. The clinical illness caused by specific hantaviruses remains to be precisely defined.

Military Impact and Historical Perspective. During World War I, an epidemic of "trench nephritis" may have been due to hantaviral infection. Thousands of cases of this illness, considered an entirely new disease, were noted on both sides of the Western front. Prior to World War II, Japanese and Soviet authors described HFRS along the Amur River in Manchuria. During World War II, more than 10,000 cases of a leptospirosis-like disease were recorded during the 1942 German campaign in Finnish Lapland. When the snow melted, great numbers of lemmings and field mice invaded German bunkers. In 1951, HFRS was recognized among United Nations troops in Korea. A retrospective study of sera collected from 245 patients diagnosed with hemorrhagic fever during the Korean conflict confirmed that these cases were due to HTN. Cases are reported annually among U.S. forces deployed to South Korea. Fourteen of 3,754 U.S. Marines who participated in a joint training exercise during the autumn of 1986

developed HFRS, and 2 died. This outbreak was the largest cluster of HFRS cases among U.S. personnel in the Republic of Korea since the Korean War. Up to 30% of rodents collected from training areas in the demilitarized zone have been seropositive for hantaviruses.

Hantaviral disease is an emerging medical threat to military forces operating in many areas of the world. Over 20 acute PUU infections were documented in U.S. Army personnel during a 1990 field exercise in southern Germany. Several outbreaks of hantaviral disease occurred in 1995 as a result of the civil war in the states of the former Yugoslavia. Over 300 patients, most of them soldiers exposed in the field, were hospitalized in the Tuzla region (northeast Bosnia) with acute hantaviral disease. Outbreaks also occurred around Sarajevo and Zenica. Over 100 cases were reported in northern Montenegro. Hantaviral infections also occurred during the fighting in Kosovo. Advanced diagnostic techniques have led to increasing recognition of new hantaviruses and hantaviral infections globally. New outbreaks with novel hantaviral strains are still being uncovered. The distribution of new and old strains of hantaviruses presents a complex and confusing epidemiological picture of this emerging disease. Its military threat is significant.

Disease Distribution. At least 200,000 cases of HFRS involving hospitalization are reported annually throughout the world. HFRS is the most common cause of acute renal failure in East Asia and is a major health problem in China and Korea.

China: HTN virus claims 50,000 to 100,000 victims annually in China. HFRS is focally distributed countrywide but occurs primarily in hilly areas under 500 m and east of 100° E longitude from Yunnan Province in the south to Heilongjiang Province in the northeast. The disease is absent in mountainous and plateau regions above 2,000 m. In 1997, only Qinghai Province and Xinjiang Autonomous Region did not report cases. There is a nearly equal incidence of HTN and SEO viruses. HTN virus infection is occupationally associated with farming, camping, and military exercises. Risk of transmission is greater under dry, dusty conditions and when there are large populations of the striped field mouse, *Apodemus agrarius*. SEO virus infection is associated with large populations of *R. norvegicus* in urban settings. A recent study in Jiangsu Province found a significant correlation between HFRS incidence and indoor density of *Rattus norvegicus*. Transmission can occur year-round, but the incidence of HFRS caused by HTN virus in rural areas of Zhejiang Province exhibits a major peak in November and a minor peak in June. Both epidemic seasons coincide with peaks of the *A. agrarius* population and local agricultural activities. SEO virus infections occur primarily during the months of December through May as a result of exposure to domestic rodents in the home. Similar patterns of transmission have been observed in other areas of China.

Japan: HFRS is enzootic at low levels in Japan. SEO virus has been the only virus associated with human infections. *Rattus norvegicus* and *R. rattus* are the reservoirs. The highest rodent infection rates have been found in major port cities. Thirty-five percent of *R. norvegicus*

collected from Tokyo Port were seropositive in 1983. In 1995, a PUU virus strain was isolated from *Clethrionomys rufocanus* trapped in 7 of 8 collection sites in Hokkaido Prefecture.

Korea: South Korea has reported about 1,000 cases annually in recent years. The two serotypes of hantavirus, HTN and SEO viruses, are known pathogens for nearly all cases of HFRS in Korea. However, in 1991, cases of HFRS attributed to PUU were reported for the first time from South Korea. This virus is associated with *Clethrionomys* species of mice. Most indigenous human cases occur from October through December and are associated with agricultural activities in fields infested with *A. agrarius*. Infections with SEO virus result from close association with *R. norvegicus* and *R. rattus*. A virus closely related to HTN virus was isolated from 2 species of bats in South Korea, indicating that bats may serve as reservoirs of hantavirus. Similar epidemiological patterns of the disease exist in North Korea.

Mongolia: All confirmed cases of HFRS in Mongolia have been attributed to HTN and associated with occupational exposure to *A. agrarius*. However, SEO virus infection of domestic rodents is widespread in neighboring China, and PUU virus infection associated with bank voles (*Clethrionomys* spp.) is enzootic in neighboring Russia and Kazakhstan. The likelihood of these viruses occurring in Mongolia is significant.

Taiwan: Few cases of HFRS have been reported from Taiwan. The first confirmed case of HFRS in Taiwan occurred in 1995, but this proved to be imported. A survey of 16 species of rodents trapped throughout Taiwan found evidence of a mild strain of the SEO virus. Serological studies indicate that hantaviruses may be more widespread in Taiwan than previously believed. Up to 20% of *R. rattus* had HTN viral antibodies in some parts of Taiwan. Prevalence of human hantaviral antibodies increased with age in garbage collectors, animal handlers, and patients with febrile illness of unknown origin.

Transmission Cycle(s). Virus is present in the urine, feces and saliva of persistently infected asymptomatic rodents. Aerosol transmission to humans from rodent excreta is the most common mode of infection. Attempts to isolate hantaviruses from rodent ectoparasites have largely failed, but experimental evidence indicates that various haemogamasid mites may pass the virus between reservoir rodents. Human to human transmission of HFRS is considered rare, although viruses have been isolated from the blood and urine of patients. Hantaviruses have caused laboratory-associated outbreaks of infection.

Each hantavirus appears to have a single predominant murid reservoir. HTN is commonly associated with the field mouse, *A. agrarius*, in open field or unforested habitats. The red bank vole, *C. glareolus*, inhabits woodland or forest-steppe environments and is a primary reservoir for PUU. DOB has been isolated from the yellow-necked field mouse, *A. flavicollis*, in open fields and unforested foothills. The domestic rat, *R. norvegicus*, is the reservoir for SEO worldwide. The common European vole, *Microtus arvalis*, appears to be the primary reservoir

of TUL. Hantavirus infection is not pathogenic in its rodent reservoir and produces chronic and probably lifelong infection. Hantaviruses may be spread by infected rodents that infest ships which subsequently dock at ports worldwide. A serological survey of rodents in Taiwan found a much higher hantaviral antibody prevalence in international seaports than in domestic seaports.

The risk of transmission is highest in warm months when rodent reservoir populations are abundant. Military personnel are exposed to infection when working, digging or sleeping in fields and shelters infested by infected rodents.

Disease Prevention and Control. To prevent hantaviral disease, exclude or prevent rodent access to buildings. Food should be stored in rodent-proof containers or buildings. Disinfect rodent-contaminated areas with dilute bleach or other antiviral agents. Do not sweep or vacuum rodent-contaminated areas; use a wet mop moistened with disinfectant. Eliminate wild rodent reservoirs before military encampments are established in fields. Do not disturb rodent droppings or sleep near rodent burrows. Military personnel should not feed or tame wild rodents. Rodents frequently urinate or bite when handled. Detailed information on surveillance and personal protective measures when working around potentially infected rodents can be found in TIM 40, Methods for Trapping and Sampling Small Mammals for Virologic Testing, and in TIM 41, Protection from Rodent-borne Diseases.

VIII. Noxious/Venomous Animals and Plants of Military Significance.

A. Arthropods.

Annoyance by biting and stinging arthropods can adversely affect troop morale. The salivary secretions and venoms of arthropods are complex mixtures of proteins and other substances that are allergenic. Reactions to arthropod bites and stings range from mild local irritation to systemic reactions causing considerable morbidity, including rare but life-threatening anaphylactic shock. Insect bites can be so severe and pervasive that they affect the operational readiness of troops in the field. Bites and their discomfort have been a major complaint by soldiers deployed in many regions of the world.

Entomophobia, the irrational fear of insects, and the related arachnophobia, fear of spiders, are two of the most common human phobias. The fear is usually not limited to obvious threats, such as scorpions. The anxiety produced in a fearful individual by a potential encounter with an insect range from mild aversion to panic. The degree of negative response to encounters with insects or spiders is important in assessing the difference between common fear and true phobia. Common fear is a natural extension of human experience and is appropriate to situations that involve potential danger or require caution. Phobias, however, are characterized by persistent, high levels of anxiety in situations of little or no threat to the individual. Many individuals may express a fear of insects or spiders, but few are phobic to the extent that their ability to function in a normal daily routine is impaired by their fear. The term delusory parasitosis refers to a mental disorder in which an individual has an unwarranted belief that insects or mites are infesting his or her body or environment. This psychiatric condition is distinct from entomophobia or an exaggerated fear of real insects. Extreme entomophobia and delusory parasitosis require psychological treatment.

The following groups of noxious arthropods are those most likely to be encountered by military personnel operating in countries of East Asia:

1. Acari (ticks and mites). Scabies is the most important disease caused by mite infestation, and infestations have been common during military conflict. During World War I, scabies infestations occurred at a rate of 20 per 1,000 soldiers per year among American forces in Europe. During World War II, nearly 100,000 cases were reported in American troops. Five percent of the residents of London became infested with scabies during the bombing of the city by the German Air Force. During the Falklands War of 1982, scabies became such a problem among Argentine troops that their fighting efficiency was significantly impaired.

Sarcoptes scabiei (family Sarcoptidae) is a parasitic mite that spends its entire life cycle in burrows in the skin of mammals. Mite infestations cause scabies in man and mange in other animals, including primates, horses, wild and domestic ruminants, pigs, camels, rabbits, dogs and other carnivores. Populations found on different host species differ physiologically more

than morphologically and are referred to as forms (those on man, for instance, are *S. scabiei* form *hominis*). Some authors may refer to forms as varieties or even subspecies. All forms are considered to be the same species, *S. scabiei*. Mites from one host species do not establish themselves on another. Humans can become infested with scabies mites from horses or dogs, but such infestations are usually mild and disappear without treatment. *Sarcoptes* mites are common on domestic animals in East Asia, especially stray dogs, and troops should avoid contact with local animals.

Scabies mites principally burrow in the interdigital and elbow skin, but skin of the scrotum, breasts, knees and buttocks is also affected. The face and scalp are rarely involved. Scabies mites are very small, about 0.2 to 0.4 mm. Both sexes burrow in the horny layer of the skin, but only the female makes permanent burrows parallel to the skin surface. Burrowing may proceed up to 5 mm per day, and the burrow may extend over a cm in length. Mites feed on liquids oozing from dermal cells that have been chewed. Females lay 1 to 3 eggs per day in their tunnels and rarely leave their burrows. Eggs hatch into six-legged larvae that crawl out of the burrows onto the surface of the skin. Larvae burrow into the skin or a hair follicle and form a pocket in which they molt into the nymphal stage. Nymphs molt into adults, and the male burrows into the molting pocket in the skin and mates with the female. The female begins to burrow through the skin only after fertilization. Adult males can be found in short burrows or pockets in the skin or wandering around on the skin surface. The life cycle from egg to adult takes about 10 to 14 days. Adult females live about a month on humans but survive only a few days off the host. Clothing or bedding kept unused for about 5 days is usually free of mites. Scabies is transmitted from person to person by close, prolonged personal contact. Transmission is common in dormitories, barracks and medical facilities. It is possible to get infested by sleeping in a bed formerly occupied by an infested person, but experimental work has indicated this rarely happens. Exposure for ten minutes at 50°C will kill mites. In newly infested persons, a period of 3 to 4 weeks usually elapses before sensitization to mites and mite excretions develops. Itching is not experienced during this period, and infestations may progress extensively before being noticed. However, fewer than 20 mites are enough to produce intense itching, particularly at night. The burrows often become secondarily infected with bacteria causing pustules, eczema and impetigo. In infested persons, an extensive rash can cover areas where there are no mites, and a rash may persist for several weeks after all scabies mites have been killed. In immunocompromised individuals, who do not respond to infestation by itching and scratching, mites can reach very high populations and produce a scaly crusted skin known as Norwegian or crusted scabies. With a highly contagious condition like scabies it is important to treat all persons living in close association with an infested individual.

Sarcoptes scabiei is cosmopolitan and infestations are likely to be encountered in some parts of East Asia, particularly in rural areas of China, Mongolia, and North Korea. Persons of all ages are affected, although in most developing countries infestation is highest in poor communities and in children. Infestation is more common in overcrowded areas with poor hygiene, and

incidence increases during wars and natural disasters. Scabies is not a reportable disease in most countries; thus, estimated rates of infestation are usually inaccurate. Scabies is usually only reported when large outbreaks occur. Increases in the incidence of scabies appear to occur in 15 to 20 year cycles that are related to fluctuating levels of immunity to *S. scabiei* in the human population. Infestations with scabies and other ectoparasites were common in Japan after World War II but declined as socio-economic conditions improved. However, the incidence of scabies has increased since the mid 1980s. Incidence of human scabies peaked in Korea during 1981 to 1982, when nearly 10% of outpatients of the dermatology clinic at Chonbuk National University were infested. Incidence decreased dramatically during the next 10 years and has remained below 1% since 1990. During a 1998 survey by dermatologists, 1.4% of 3,029 students from 4 rural districts and 1 urban area of Taitung County, Taiwan, were infested. Infestations were significantly more common in rural areas than in the urban area.

Larvae of the mite family Trombiculidae are known variously as chiggers, harvest mites and scrub itch mites and are parasites of mammals and birds. Over 3,000 species have been described worldwide but only about 30 of these are known to attack humans. Larvae are very small, measuring about 0.25 mm long, and are often called red bugs. Females lay eggs in damp soil. The eggs hatch into six-legged larvae that congregate near the tips of grass and fallen leaves and attach to passing animals that brush against the vegetation. Larvae cluster in the ears of rodents and around the eyes of birds. On humans they most often attach where the clothing is tight, around the waist or genitals. Chigger larvae do not burrow into the skin as commonly believed, nor do they feed primarily on blood. Larvae remain on the skin surface and use digestive fluids to form a feeding tube (stylostome) that enables them to feed on cellular material for several days. Fully fed larvae drop to the ground to continue their complex life cycle. In the nymphal and adult stages, they are believed to prey on the eggs and larvae of other arthropods. Feeding by chiggers can cause an intense itchy dermatitis leading to pustules and sometimes to secondary infection. Most temperate zone chiggers have one annual generation.

Tick paralysis is a potentially fatal but easily cured affliction of man and animals. It is almost exclusively associated with hard (ixodid) ticks and is caused by injection of neurotoxin(s) in tick saliva. The toxin, which may be different in different species, disrupts nerve synapses in the spinal cord and blocks the neuromuscular junctions. Worldwide, nearly 50 species of hard ticks have been associated with tick paralysis, although any ixodid tick may be capable of producing this syndrome. A tick must be attached to its host for 4 to 6 days before symptoms appear. This condition is characterized by an ascending, flaccid paralysis, usually beginning in the legs. Progressive paralysis can lead to respiratory failure and death. Diagnosis simply involves finding the embedded tick, usually at the base of the neck or in the scalp. After tick removal, symptoms resolve within hours or days. However, if paralysis is advanced, recovery can take several weeks. No drugs are available for treatment.

Most tick bites are painless, produce only mild local reaction, and frequently go unnoticed. However, dermal necrosis, inflammation or even hypersensitivity reactions may occur within a few days of tick attachment. After tick removal, a reddened nodule may persist for weeks or months. Tickbite wounds can become infected with *Staphylococcus* and other bacteria causing local cutaneous abscesses. The bite of the cave tick, *Ornithodoros tholozani*, produces deep red, crusted nodules or papules up to 1.5 cm in diameter. *Ixodes nipponensis* is one of the most common species of ticks responsible for tick bites in South Korea. The bite frequently results in panniculitis with firm nodules 1 to 4 cm in diameter forming in the subcutaneous fatty tissue of the skin. Tick toxicosis is a systemic reaction to tick saliva. Tickbite anaphylaxis has rarely been reported, but studies in Australia suggest it is more common and potentially life threatening than tick paralysis. Tick removal and other personal protective measures against ticks are discussed in Appendix E.

2. Araneae (spiders). More than 35,000 species of spiders have been described worldwide. All spiders, with the exception of the family Uloboridae, are venomous and use their venom to immobilize or kill prey. Most spiders are harmless because their chelicerae cannot penetrate human skin, or they have venom of low toxicity to humans. Only about a dozen species have been responsible for severe systemic envenomization in humans, although as many as 500 species may be capable of inflicting significant bites. Those that can bite humans are rarely seen or recovered for identification, so physicians need to be able to recognize signs and symptoms of common venomous spider bites in order to administer appropriate therapy. In East Asia the widow spiders, *Latrodectus* spp. (family Theridiidae), and the sac spiders, *Chiracanthium* spp. (family Clubionidae), are responsible for significant local and systemic effects from envenomization.

The black widow, *L. mactans*, is widespread throughout the region. This species is also referred to as the hourglass, shoe button, or po-ko-moo spider. The brown widow, *L. geometricus*, has been reported from Japan only since the mid 1990s. It is more common in warm climates, and is more likely to be found in human habitations than other widow spiders in the region. The redback spider, *Latrodectus hasseltii*, is a common venomous spider in Australia. This species was not known in Japan until it was collected and identified in Osaka Prefecture in the autumn of 1995. Since then, many redback spiders have been found in extensive areas of Osaka and Mie Prefectures. It is tolerant of cold temperatures and will probably become established throughout Japan. Considerable variation in coloration and markings exists between species and between immatures and adults of *Latrodectus* spp. Widow spiders are found in various habitats in the wild, especially in protected places, such as crawl spaces under buildings, holes in dirt embankments, piles of rocks, boards, bricks or firewood. Indoors, they prefer dark areas behind or underneath appliances, in deep closets and cabinets. They commonly infest outdoor privies, and preventive medicine personnel should routinely inspect these structures. Widow spiders spin a crude web and usually will not bite unless provoked.

Latrodectus spp. inject a potent neurotoxin when biting. The bite itself is mild and most patients do not remember being bitten. Significant envenomization results in severe systemic symptoms, including painful muscle spasms, a rigid board-like abdomen, and tightness in the chest. Mortality rates from untreated bites have been estimated at 1 to 5%. Most envenomizations respond quickly to sustained intravenous calcium gluconate. Antivenins are commercially available and very effective.

Sac spiders of the genus *Chiracanthium* have a cytolytic venom that produces cutaneous necrosis in victims, although the necrotizing lesions are usually not as severe as those produced by the bite of *Loxosceles* spp. Some species have neurotoxic components in their venom. Over 150 species of sac spiders have been recorded worldwide. The consequences of bites include severe local pain, fever, swelling and redness, with a small area of necrosis at the site of the bite. *Chiracanthium japonicum* is responsible for many bites in Japan and is considered the most medically important spider in that country.

3. Ceratopogonidae (biting midges, no-see-ums, punkies). The Ceratopogonidae is a large family containing nearly 5,000 species in over 60 genera. These extremely small flies (1 to 2 mm) can easily pass through window screens and standard mosquito netting, although most species feed outdoors. Their small size is responsible for the moniker "no-see-ums." Many species in this group attack and suck fluids from other insects. Most species that suck vertebrate blood belong to the genera *Culicoides* (1,000 species) or *Leptoconops* (about 80 species). Only females suck blood. In East Asia, these insects do not transmit human diseases, but they do serve as vectors for several diseases of veterinary importance. Many species of Ceratopogonidae are widespread in the region, but little is known about their biology. Many species of *Culicoides* are zoophilic. *Leptoconops* are more likely to be a major nuisance to man. However, *Forcipomyia taiwana* is one of the most annoying blood-sucking pests in Taiwan. It is distributed island-wide in urban and suburban habitats, including scenic sites and public parks. Populations of this species have dramatically increased as a result of agricultural practices on the island. *Forcipomyia taiwana* attacks exposed parts of the body during the day, causing intense pruritis and swelling in sensitive individuals. Blood-sucking species predominately feed and rest outdoors, entering houses in much smaller numbers. *Leptoconops* are active during the day; *Culicoides* may be either diurnal or nocturnal. Diurnal species of both genera prefer early morning and late afternoon periods. Despite their small size, they often cause local reactions severe enough to render a military unit operationally ineffective. In sensitive people, bites may blister, exude serum and itch for several days, or be complicated by secondary infections from scratching. Enormous numbers of these tiny flies often emerge from breeding sites, causing intolerable annoyance. Most species remain within 500 m of their breeding grounds, although some species of *Culicoides* and *Leptoconops* are known to fly 2 to 3 km without the assistance of wind. Ceratopogonidae are troublesome mainly under calm conditions, and the number of flies declines rapidly with increasing wind speed.

Breeding habits vary widely from species to species. The larvae are primarily aquatic or semiaquatic, occurring in the sand or mud of fresh, salt, or brackish water habitats, notably salt marshes and mangrove swamps. Some important species breed in sandy areas near the seashore, where they can be a serious economic threat to the tourist industry. There are 4 larval instars, and a fully grown larva is only about 5 to 6 mm long. In warm climates larval development is completed within 14 to 25 days. Many species exploit specialized habitats such as tree holes, decaying vegetation, and cattle dung. In militarily secure areas, encampments should be located in the open, away from breeding sites, to avoid the nuisance caused by these insects.

Larvae are difficult to find, but adults are easily collected while biting and with light traps. Environmental management best controls larval stages, but this may be impractical in extensive or diffuse habitats. Adult control typically includes applying residual insecticides to fly harborages, treating screens and bednets with pyrethroids, and using repellents. Ultra low volume application of aerosols may produce temporary control, but sprayed areas are soon invaded by midges from unsprayed areas. Ceratopogonids have difficulty biting through clothing because of their short mouthparts, so even an untreated BDU can provide considerable protection.

4. Chilopoda (centipedes) and Diplopoda (millipedes). Centipedes in tropical countries can attain considerable size. Members of the genus *Scolopendra* can be over 25 cm long and are capable of inflicting painful bites, with discomfort lasting 1 to 5 hours. Several species of this genus known to bite man occur in East Asia. *Scolopendra subspinipes mutilans*, *S. subspinipes multidens* and *S. mojiangica* are widespread tropical species that are most often incriminated in human bites. Specimens up to 30 cm in length have been collected in Taiwan. *Scolopendra* bites produce excruciating local pain, erythema and swelling. Centipedes bite using their first pair of trunk appendages (maxillipeds), which have evolved into large, claw-like structures. Two puncture wounds at the site of attack characterize a centipede bite, and they are sometimes confused with the bite marks of a viper. Neurotoxic and hemolytic components of a centipede's venom normally produce only a localized reaction, but generalized symptoms such as vomiting, irregular pulse, dizziness and headache may occur. Most centipede bites are uncomplicated and self-limiting, but secondary infections can occur at the bite site. Centipede bites are rarely fatal to humans. Centipedes are used in many parts of East Asia in traditional medicine to treat arthritis and other ailments.

Centipedes are flattened in appearance and have 1 pair of legs per body segment. Large species may have over 100 pairs of legs. They are fast-moving, nocturnal predators of small arthropods. During the day, they hide under rocks, boards, bark, stones and leaf litter, but occasionally they find their way into homes, buildings, and tents. Centipedes are not aggressive and seldom bite unless molested. Most centipede bites occur when the victim is sleeping or when putting on clothes in which centipedes have hidden. Troops should be taught to inspect clothing and footwear when living in the field.

Millipedes are similar to centipedes except that they have two pairs of legs per body segment and are rounded or cylindrical instead of flattened. Millipedes are commonly found under stones, in soil and in leaf litter. They are nocturnal and most species feed on decaying organic matter. They are more abundant during the wet season. When disturbed they coil up into a tight spiral. Millipedes do not bite or sting, but some species secrete defensive body fluids containing quinones and cyanides that discolor and burn the skin. An initial yellowish-brown tanning turns to deep mahogany or purple-brown within a few hours of exposure. Blistering may follow in a day or two. Eye exposure may require medical treatment. A few species from the genera *Spirobolida*, *Spirostreptus*, and *Rhinocrichus* can squirt their secretions a distance of 80 cm or more. The *Parafontaria laminata* group of millipedes become so abundant during the autumn in central Japan that outbreaks have stopped trains.

5. Cimicidae (bed bugs). There are over 90 species in the family Cimicidae. Most are associated with birds and/or bats and rarely bite humans. The common bed bug, *Cimex lectularius*, has been associated with humans for centuries and is cosmopolitan in distribution. The tropical bed bug, *Cimex hemipterus*, also feeds on humans and is similar in appearance to *C. lectularius*. It is common in tropical areas of Asia, Africa and Central America. Bed bug infestations are typical of unsanitary conditions, but they can still be found in developed countries. There is little evidence that bed bugs transmit any pathogens. Bites can be very irritating, prone to secondary infection after scratching, and may produce hard swellings or welts. Bed bugs feed at night while their hosts are sleeping but will feed during the day if conditions are favorable. During the day they hide in cracks and crevices, under mattresses, in mattress seams, spaces under baseboards, or loose wallpaper. Chronic exposure to bed bugs can result in insomnia, nervousness and fatigue. Some studies have found that a high percentage of asthmatic patients had positive skin reactions to *Cimex* antigen. A 1995 study in Nanjing, Jiangsu Province, China, demonstrated that 63% of 320 bronchial asthma patients showed a positive skin test to bed bug allergens.

Five nymphal instars precede the adult stage. Each nymph must take a bloodmeal in order to molt. Adults live up to 1 year. Bed bugs take about 5 minutes to obtain a full bloodmeal. They can survive long periods of time without feeding, reappearing from their hiding places when hosts become available. Females may live several months and lay 50 to 200 eggs over their lifetime. Bed bugs possess scent glands and emit a characteristic odor that can easily be detected in heavily infested areas. Blood spots on bedding or “bedclothes” and fecal deposits are other signs of infestation. Eggs and cast nymphal skins may be observed in cracks and crevices.

Infestations of bed bugs in human habitations are not uncommon in many areas of East Asia. Bed bugs can be introduced into barracks through infested baggage, bedding and belongings. They may pass from the clothing of one person to another on crowded public vehicles. In the absence of humans, bed bugs will feed on rats, mice, bats or birds. Therefore, old dwellings should be surveyed for these and other pests before they are occupied during contingency

situations. *Cimex lectularius* and *C. hemipterus* commonly feed on poultry in many parts of the region, so poultry houses should be avoided by military personnel.

6. Dipterans Causing Myiasis. Myiasis refers to the condition of fly maggots infesting the organs and tissues of people or animals. Worldwide there are 3 major families of myiasis-producing flies: Oestridae, Calliphoridae and Sarcophagidae. The Oestridae contains about 150 species known as bot flies and warble flies. They are all obligate parasites, primarily on wild or domestic animals. Members of the genera *Cuterebra* and *Dermatobia* commonly infest humans in the Americas. The Calliphoridae, known as blow flies, are a large family composed of over 1,000 species. At least 80 species, mostly in the genera *Cochliomyia*, *Chrysomyia*, *Calliphora* and *Lucilia*, have been recorded as causing cutaneous myiasis. Flies in the genus *Lucilia* are known as greenbottle flies due to their metallic or coppery green color. *Lucilia sericata* and *L. cuprina* are the most common species infesting wounds of humans. *Calliphora* flies are commonly called bluebottle flies because of their metallic-bluish or bluish-black color. The abdomen is usually more shiny than the thorax. The family Sarcophagidae, known as flesh flies, contains over 2,000 species, but the only important genera in terms of myiasis are *Wohlfahrtia* and *Sarcophaga*. The abdomen of flesh flies is often marked with squarish dark patches on a grey background, giving it a checkerboard appearance. Females are larviparous and deposit first-instar larvae instead of eggs. The larvae are deposited in batches of 40 to 60 on decaying carcasses, rotting food and human or animal feces.

Myiasis is also classified according to the type of host-parasite relationship, and specific cases of myiasis are clinically defined by the affected organ, e.g., cutaneous, enteric, rectal, aural, urogenital, ocular, etc. Myiasis can be accidental when fly larvae occasionally find their way into the human body. Accidental enteric myiasis occurs from ingesting fly eggs or young maggots on uncooked foods or previously cooked foods that have been subsequently infested. Other cases may occur from the use of contaminated catheters, douching syringes, or other invasive medical equipment in field hospitals. Accidental enteric myiasis is usually a benign event, but larvae may survive temporarily, causing stomach pains, nausea, or vomiting. Numerous fly species in the families Muscidae, Calliphoridae, and Sarcophagidae are involved in accidental enteric myiasis. A common example is the cheese skipper, *Piophila casei* (family Piophilidae), which infests cheese, dried meats and fish.

Facultative myiasis occurs when fly larvae infest living tissues opportunistically after feeding on decaying tissues in neglected wounds. Considerable pain and injury may be experienced as fly larvae invade healthy tissues. Facultative myiasis has been common in wounded soldiers throughout military history, and numerous species of Muscidae, Calliphoridae, and Sarcophagidae have been implicated. Species of these families are widespread throughout East Asia. Surgeons used maggots that feed only on necrotic tissues to clean septic battle wounds until about the 1950s. Maggot therapy has been used in recent years to treat chronically infected tissues, especially osteomyelitis.

Myiasis is obligate when fly larvae must develop in living tissues. This constitutes true parasitism and is essentially a zoonosis. Obligate myiasis is a serious pathology. In humans, obligate myiasis results primarily from fly species that normally parasitize domestic and wild animals. The sheep bot fly, *Oestrus ovis,* is found wherever sheep are raised. Larvae are obligate parasites in the nostrils and frontal sinuses of sheep, goats, camels and horses. Human ocular infestation by *O. ovis* is common in East Asia. Several cases occurred in U.S. military personnel during the Persian Gulf War. Female flies are larviparous, depositing larvae while in flight directly into the human eye. Normally, infestations produce a painful but not serious form of conjunctivitis. However, larvae are capable of penetrating to the inner eye, causing serious complications.

The Old World screw-worm fly, *Chrysomyia bezziana* (family Calliphoridae), is a common myiasis-producing fly from Southeast Asia to China. Adult *C. bezziana* only oviposit on live mammals, depositing 150 to 500 eggs at wound sites or in body orifices (ears, nose, mouth and urogenital openings). The larvae hatch in 18 to 24 hours, molt once after 12 to 18 hours, and a second time about 30 hours later. They feed for 3 to 4 days and drop to the ground to pupate. The pupal stage lasts 7 to 9 days under tropical conditions. *Chrysomya megacephala* is common in some parts of East Asia and is often called the Oriental latrine fly because of its habit of breeding in feces as well as on carrion and other decomposing organic matter. It can occur in large numbers around latrines and become a nuisance in open-air meat and fish markets. The larvae can cause a secondary myiasis of wounds in man and animals.

Myiasis is rarely fatal, but troops living in the field during combat are at high risk of infestation. Good sanitation can prevent most cases of accidental and facultative myiasis. To prevent flies from ovipositing on them, exposed foodstuffs should not be left unattended. Fruits and vegetables should be washed prior to consumption and examined for developing maggots. Extra care should be taken to keep wounds clean and dressed. Avoid sleeping in the nude, especially outdoors during daytime when adult flies are active and likely to oviposit in body orifices. At field facilities, proper waste disposal and fly control can reduce fly populations and the risk of infestation.

Several other species of flies commonly cause myiasis in cattle (e.g., *Hypoderma* spp.) and in horses and donkeys (e.g., *Gasterophilus* spp.), and their larvae sometimes infest humans. The larvae of most species of flies are extremely difficult to identify. Geographic location and type of myiasis are important clues to identity. It is particularly helpful to rear larval specimens so that the adult can be used for identification.

7. Hymenoptera (ants, bees and wasps). Most wasps and some bees are solitary or subsocial insects that use their stings for subduing prey. These species are not usually involved in stinging incidents, and their venom generally causes only slight and temporary pain to humans. The

social wasps, bees and ants use their sting primarily as a defensive weapon, and their venom causes intense pain in vertebrates.

The 3 families of Hymenoptera responsible for most stings in humans are the Vespidae (wasps, hornets, and yellow jackets), the Apidae (honey bees and bumble bees), and the Formicidae (ants). Wasps and ants can retract their stings after use and can sting repeatedly. The honey bee stinging apparatus has barbs that hold it so firmly that the bee's abdomen ruptures when it tries to pull the stinger out of the skin. The bee's poison gland, which is attached to the stinger, will continue injecting venom after separation. Scraping the skin after a bee sting is important to remove the stinger and attached venom sac. Honey bees and social wasps of the family Vespidae account for most stings requiring medical treatment in East Asia. Wild strains of honey bees may be more aggressive than domesticated populations maintained by beekeepers. *Apis cerana* is a common cavity-nesting honey bee that occurs in Asia, from Afghanistan to China and from Japan to southern Indonesia. The largest honey bees in the world, *Apis laboriosa* and *A. dorsata*, are found in Central Asia. *Apis dorsata* occurs from Pakistan through the Indian Subcontinent and Sri Lanka to Indonesia and parts of the Philippines. The closely related, slightly larger *A. laboriosa* is believed to be restricted to the Himalayas. The nests of both of these species are harvested by local people for honey and wax, and sometimes brood, which are eaten in Nepal and elsewhere. *Apis laboriosa* makes its nests on the sides of cliffs, and *A. dorsata* builds nests under tree limbs and cliffs. These bees will aggressively defend their nests and sometimes pursue attackers for over 100 m. The world's smallest honey bee, *Apis florae*, occurs from Oman, Iran and Pakistan through the Indian Subcontinent and Sri Lanka to Indonesia. *Apis florae* is most abundant in Southeast Asia, and it is not found north of the Himalayas.

The black-bellied hornet, *Vespa basalis,* is the most dangerous species of vespid wasp in Taiwan and possesses a highly toxic venom rich in biologically active enzymes and peptides. The yellow-legged hornet, *Vespa verutina*, is widely distributed in both mountainous areas and suburbs of Taiwan and also possesses a highly toxic venom. In Japan, an average of 37 fatalities per year were reported during the years 1979 to 1988 as a result of bee and wasp stings. The Japanese hornet, *Vespa simillima*, is one of the most common wasps in Japan and is a nuisance pest in residential and urban areas. It frequently nests in domestic structures and constructs the largest nest of all Japanese hornets. *Vespa mandarinia* is a very large Japanese hornet that causes a very painful sting.

Ants can bite, sting and squirt the contents of the poison gland through the tip of the abdomen as defensive secretions. The components of the venom are complex and vary with the species of ant. Formic acid is a common substance discharged as a defensive secretion. The Samsum ant, *Pachycondyla sennaarensis*, has been responsible for many hypersensitive reactions in South Korea. Some protein-feeding ants such as the Pharaoh ant, *Monomorium pharaonis,* have been incriminated as mechanical vectors of pathogens in hospitals.

Hymenoptera venoms have not been fully characterized but contain complex mixtures of allergenic proteins and peptides as well as vasoactive substances, such as histamine and norepinephrine. These are responsible for the pain at the sting site, irritation, redness of the skin, and allergic reactions in sensitized individuals. There is no allergic cross-reactivity between honey bee and vespid venoms, although cross-reactivity may exist to some extent between different vespid venoms. Therefore, a person sensitized to one vespid venom could have a serious reaction to the sting of another member of the vespid family.

Reactions to stings may be grouped into 2 categories, immediate (within 2 hours) or delayed (more than two hours). Immediate reactions are the most common and are subdivided into local, large local, or systemic allergic reactions. Local reactions are nonallergic responses characterized by erythema, swelling, and transient pain at the sting site that subsides in a few hours. Stings in the mouth or throat may require medical assistance. Multiple stings in a short period of time may cause systemic symptoms such as nausea, malaise and fever. It generally takes 500 or more honey bee stings to kill an adult by the toxic effects of the venom alone. The toxicity of African honey bee venom is roughly equivalent to the toxicity of the venom of domesticated honey bees. Large local reactions are characterized by painful swellings at least 5 cm in diameter and may involve an entire extremity. Systemic reactions vary from mild urticaria to more severe reactions, including vomiting, dizziness and wheezing. Severe allergic reactions are rare but can result in anaphylactic shock, difficulty in breathing, and death within 30 minutes. Emergency kits should be provided to patients who have experienced anaphylactic reactions to stings. Commercial kits are available that include antihistamine tablets and syringes preloaded with epinephrine. Sensitive individuals should also consider wearing a Medic-Alert tag to alert medical personnel of their allergy in case they lose consciousness. Venom immunotherapy for sensitive individuals will reduce but not eliminate the risk of anaphylactic reactions. The frequency of sting hypersensitivity is probably less than 1% of the population.

Delayed reactions to Hymenoptera envenomization are uncommon but usually present as a large local swelling or, rarely, as systemic syndromes. The cause of delayed reactions is unclear and may not always involve immunologic mechanisms.

Individuals can practice a number of precautions to avoid stinging insects. Avoid wearing brightly colored floral-pattern clothes. Do not go barefoot in fields where bees and wasps may be feeding at ground level. Avoid the use of scented sprays, perfumes, shampoos, suntan lotions, and soaps when working outdoors. Be cautious around rotting fruit, trash containers, and littered picnic grounds, since large numbers of yellow jackets often feed in these areas. Avoid drinking sodas or eating fruits and other sweets outdoors, since bees and yellow jackets are attracted to these items. Bees and wasps are most aggressive around their nests, which should not be disturbed.

8. Lepidoptera (urticating moths and caterpillars). The caterpillars of certain moths possess urticating hairs that can cause dermatitis. The hairs are usually connected to glands that release poison when the hair tips break in human skin. The intensity of the irritation varies with the species of moth, sites and extent of exposure, and the sensitivity of the individual, but usually the symptoms are temporary. Hairs stimulate the release of histamine, and resultant skin rashes last about a week. The irritation is more severe when the hairs reach mucous membranes or the eye, where they can cause nodular conjunctivitis. Urticating hairs can also become attached to the cocoon when the larva pupates, and later to the adult moth. Hairs readily become airborne. If inhaled, detached caterpillar hairs can cause labored breathing; if ingested, they can cause mouth irritation. The hairs of some species retain their urticating properties long after being shed. Hairs and setae may drop into swimming pools and irritate swimmers.

Scratching and rubbing the affected parts of the body should be avoided to prevent venomous hairs from penetrating deeply into tissues. Running water should be used to wash the hairs out of the lesion. Light application of adhesive tape and stripping it away will remove many of the hairs or spines from the skin. Acute urticarial lesions usually respond to topical corticosteroid lotions and creams, which reduce the inflammatory reaction. Oral histamines help relieve itching and burning sensations. *Euproctis* species in the family Lymantriidae are commonly involved in caterpillar dermatitis. Over 50 species are known to cause dermatitis in Japan, most commonly *E. pseudoconspera*, *E. subflava* and *E. silimis*. During 1972, over 500,000 people in Shanghai City and suburban counties experienced dermatitis and other medical complaints as a result of an outbreak of the tussock moth *E. silimis*. In Korea, heavy infestations of *E. flava* during adult emergence from mid-July through August expose rural inhabitants and military personnel stationed along the DMZ to the urticating hairs of this species. Army clinics have reported hundreds of cases of dermatitis in addition to inflamation of the eyes, nose and throat. *Setora postornata* and *S. sinensis*, family Limacodidae, are frequently responsible for cases of dermatitis in China. The pine moth, *Dendrolimus punctatus* (family Lasiocampidae), occurs in immense outbreaks, stripping Mason pines, *Pinus massoniana*, of their foliage in Zhejiang, Guangdong, Jiangxi and Hubei Provinces of China. Exposure to larval setae or body fluids produces severe dermatitis as well as systemic reactions affecting the joints and other parts of the body. Large numbers of people may seek medical treatment during these outbreaks. *Dendrolimus trifudus* has been reported as causing allergic dermatitis in Japan.

9. Meloidae (blister beetles), Oedemeridae (false blister beetles) and Staphylinidae (rove beetles). Blister beetles are moderate-sized (10 to 25 mm in length), soft-bodied insects that produce cantharidin in their body fluids. Cantharidin is a strong vesicant that readily penetrates the skin. Handling or crushing the beetles causes blistering within a few hours of skin contact. There is a large variation in individual susceptibility to blistering from cantharidin. Blisters are generally not serious and normally clear within 7 to 10 days without scarring. If blister beetles are ingested, cantharidin can cause nausea, diarrhea, vomiting, and abdominal cramps. Blisters that occur on the feet where they will be rubbed may need to be drained and treated with

antiseptics. Cantharidin was once regarded as an aphrodisiac, and a European species of blister beetle was popularly known as Spanish-fly. Troops should be warned against using blister beetles for this purpose, since cantharidin is highly toxic when taken orally. Insects containing cantharidin are commonly used throughout East Asia in traditional folk medicine for their irritant properties. Military personnel should be warned about the medical risks of using local folk medicines.

Approximately 1,500 species of Oedemeridae are found worldwide. They are slender, soft-bodied beetles, 5 to 20 mm in length. The adults of most species feed on pollen, so they are commonly found on flowers, but oedemerids are also readily attracted to light. Over 20 species of this family in Japan are known to contain cantharidin. Although there are few references in the medical literature, blister beetle dermatitis caused by oedemerids may be more common and widespread than currently recognized. During a training exercise on the North Island of New Zealand in 1987, 74 of 531 soldiers developed blistering after exposure to *Thelyphassa lineata.*

The Staphylinidae, commonly called rove beetles, is another family that produces a strong vesicating substance that causes blistering. Rove beetles are active insects that run or fly rapidly. When running, they frequently raise the tip of the abdomen, much as scorpions do. They vary in size, but the largest are about 25 mm in length. Some of the larger rove beetles can inflict a painful bite when handled. Many species are small (<5 mm) and can get under clothing or in the eyes. Members of the genus *Paederus* are widespread throughout the world. They have a toxin, paederin, that can cause dermatitis, painful conjunctivitis and temporary blindness after eye contact. Normally, rove beetles must be crushed to release the vesicating agent. Like beetles in the family Meloidae, rove beetles are attracted to light and and readily enter houses or other buildings at night. They can be a hazard to soldiers at guard posts. Rove beetles often emerge in large numbers after rains and can cause outbreaks of dermatitis. A 1966 outbreak of blistering on Okinawa resulted in 2,000 people seeking medical treatment. *Paederus fuscipes* is commonly implicated in outbreaks of dermatitis in East Asia. It is abundant in rice fields, where larvae and adults are predaceous on other arthropods.

10. Scorpionida (scorpions). These arthropods have a stout cephalothorax, 4 pairs of legs, a pair of large anterior pedipalps with enlarged claws, and a tail tipped with a bulbous poison gland and stinger. Some species carry the tail above the dorsum of the thorax, while others drag it behind. All species of scorpions are poisonous. However, of over 1,400 described species worldwide, fewer than 25, all in the family Buthidae, possess a venom that is life threatening to humans. Most produce a reaction in humans comparable to a bee sting. Scorpions inject the venom with a stinger on the tip of their abdomen, and some species can inflict a painful pinch with their pedipalps. They feed at night on insects, spiders and other arthropods. During the daytime, scorpions hide beneath stones, logs or bark, loose earth or among manmade objects. In dwellings, scorpions frequently rest in shoes or clothing.

Scorpions use their sting to capture prey, for defense against predators, and during mating. The venom sacs are controlled voluntarily, so a scorpion can regulate how much venom is injected with each sting. Some scorpions may not inject any venom while stinging. Scorpion venom is a complex mixture of substances that may include several neurotoxins, histamine, seratonin, enzymes, and other unidentified components. The venom of most species has never been analyzed. Some scorpion venoms are among the most toxic substances known; fortunately, only a small amount is injected, probably less than 0.5 mg. There is evidence indicating that the toxicity of any species' venom is highly variable across its geographic range. Thus, a species that is dangerous in one area may not be hazardous in another.

There are numerous scorpions in East Asia. Scorpions of the *Mesobuthus eupeus* species complex exist in China and Mongolia , and their venom is considered quite toxic. An antivenom is produced for it. The scorpion *Mesobuthus martensii* injects a mildly toxic venom that increases the heart rate and raises the blood pressure. *Mesobuthus martensii* envenomation is a common medical problem in China. This species is widely collected and cultured for use as a medicine in many countries of East Asia. *Isometrus maculatus* and *Liocheles australiasiae* have become widespread in the region, and *L. australiasiae* is common on Okinawa. Stings of *I. maculatus* are painful and cause local skin lesions. A list of scorpions reported from East Asia appears in Table 1.

Most scorpion stings are to the lower extremities or the arms and hands. Among indigenous populations, stings are more often inflicted at night, while scorpions are actively hunting for prey. Scorpion stings can occur year-round in tropical areas of East Asia. However, in areas with temperate climates, most stings are reported during the warmer months of March to October.

Scorpions can sting multiple times, and when trapped, as with a person in a sleeping bag, will readily do so, as long as the victim is active. Common places where stings are encountered by military personnel include the boots and under or around piled clothing. Scorpion stings broadly affect nearly all body tissues, and they present a mixture of hemolytic, neurotoxic and cardiotoxic effects. All stings should be considered potentially dangerous. The severity of scorpion stings can be categorized as follows: 1) patients with initial sharp pain, numbness, and localized swelling dissipating in 1 to 3 hours with no systemic findings; 2) those who, in addition to pain, have 1 or 2 mild systemic manifestations, such as local muscle spasm, dry mouth, increased salivation, or runny nose; 3) those who have more severe systemic manifestations but no central nervous system manifestation or general paralysis; and 4) those who have severe systemic reactions, including central nervous system involvement, such as confusion, convulsions, and coma, with or without general paralysis. They may also develop uncoordinated eye movements, penile swelling, or cyanosis. The most severe manifestations occur in children, who are more susceptible to the effects of venom because of their small body mass. The clinical management of scorpion envenomations is controversial. Those with type 1, 2, or 3

manifestations can be managed by applying ice to slow the spread of the venom, and supporting the patient with fluids and antihistamines. However, those with type 4 manifestations require intensive medical treatment, especially during the first 24 hours following the sting. Only in rare cases do symptoms extend beyond 72 hours. Antivenin therapy is important for severe cases. For this treatment to be effective, the stinging scorpion must be captured so it can be properly identified.

To prevent scorpion stings, military personnel should be instructed to empty boots before attempting to put them on, carefully inspect clothing left on the ground before putting it on, and keep sleeping bags tightly rolled when not in use. Also, troops must be cautioned that scorpions can cause painful reactions requiring medical treatment and should never be kept or handled as pets.

Table 1. Distribution of Scorpions in East Asia (+ = present; ? = uncertain)

Scorpion Species	China	Macau	Hong Kong	Japan	Mongolia	North Korea	South Korea	Taiwan
BUTHIDAE								
Isometrus maculatus	+	**?**	**?**	+				**?**
Lychas mucronatus	+	**?**	**?**	+				
L. scutilis	+							
Mesobuthus eupeus	+				+			
M. eupeus mongolicus	+				+			
M. eupeus thersites	+							
M. martensii		**?**	**?**	+	+	+	+	
Olivierus caucasicus	+				+			
O. caucasicus intermedius	+							
O. caucasicus przewalskii	+				+			
ISCHNURIDAE								
Liocheles australasiae	+	**?**	+	+		+	+	**?**
SCORPIOPSIDAE								
Scorpiops hardwickei	+							
S. hardwickei hardwickei	+							
S. hardwickei jendeki	+							
S. tibetanus	+							

11. Simuliidae (black flies, buffalo gnats, turkey gnats). Black flies are small (3 to 5 mm), usually dark, stout-bodied, hump-backed flies with short wings. Despite their appearance, black flies are strong flyers, and some species are capable of dispersing up to 30 km from their breeding sites. Only females suck blood, although both sexes feed on plant juices and nectars. They can emerge in large numbers and be serious pests of both livestock and humans. A characteristic of many species is the mass emergence of thousands of adults during a short period. Black flies bite during the day and in the open. Some species have a bimodal pattern of activity, with peaks around 0900 hrs in the morning and 1700 hrs in the afternoon, but in shaded areas biting is more evenly distributed throughout the day. Some species feed exclusively on birds and others on mammalian hosts. The arms, legs and face are common sites of attack, and a favorite site is the nape of the neck. Black fly bites are painful and may be itchy and slow to heal. Systemic reactions, characterized by wheezing, fever or widespread urticaria, are rare but require medical evaluation and treatment. Numerous species of anthropophilic black flies are distributed throughout East Asia and are a significant source of human discomfort. Black fly larvae usually require clean, flowing water but may be common in or near urban areas. *Simulium japonicum* and *S. uchidai* are common species in Tokyo.

12. Siphonaptera (fleas). Fleabites can be an immense source of discomfort. The typical fleabite consists of a central spot surrounded by an erythematous ring. There is usually little swelling, but the center may be elevated into a papule. Papular urticaria is seen in persons with chronic exposure to fleabites. In sensitized individuals, a delayed papular reaction with intense itching may require medical treatment.

Fleas are extremely mobile, jumping as high as 30 cm. Biting often occurs around the ankles when troops walk through flea-infested habitat. Blousing trousers inside boots is essential to provide a barrier, since fleas will crawl under blousing garters. Fleas may be encountered in large numbers shortly after entering an abandoned dwelling, where flea pupae may remain in a quiescent state for long periods of time. The activity of anyone entering such premises will stimulate a mass emergence of hungry fleas. The most common pest fleas encountered in East Asia are the cosmopolitan cat and dog fleas, *Ctenocephalides felis* and *C. canis*, the Oriental rat flea, *Xenopsylla cheopis*, and the human flea, *Pulex irritans*. Occasionally, fleas parasitizing birds nesting in human dwellings may bite humans in the absence of their hosts.

13. Solpugida (sun spiders, wind scorpions). These arthropods inhabit tropical and subtropical desert environments in Africa, Asia, Europe, and the Americas. One species, *Gylippus rickmersi*, has been reported from the Pamir plateau in Central Asia at an elevation of over 3,000 m. They usually avoid oases and other fertile places, seeming to prefer utterly neglected regions where the soil is broken and bare. Their hairy, spider-like appearance and ability to run rapidly across the ground account for their common names. Sun spiders range from 20 to 35 mm in body length and are usually pale colored. They have very large, powerful chelicerae, giving them a ferocious appearance. They can inflict a painful bite but do not have venom glands. Sun

spiders are largely nocturnal, hiding during the day under objects or in burrows. They are aggressive and voracious predators on other arthropods. They easily kill scorpions and may even capture small lizards. At night they sometimes enter tents to catch flies or other insects.

14. Tabanidae (deer flies and horse flies). Tabanids are large, stout-bodied flies with well-developed eyes that are often brilliantly colored. More than 4,000 species have been described worldwide. The larvae develop in moist or semiaquatic sites, such as the margins of ponds, salt marshes or damp earth. The immature stages are unknown for most species. Mature larvae migrate from their muddy habitats to drier areas of soil to pupate. Larval development is prolonged, and many species spend 1 to 2 years as larvae. In temperate regions the entire life cycle can take 2 years or more to complete. The larvae of horse flies are carnivorous and cannibalistic, whereas deer fly larvae feed on plant material. Consequently, deer fly populations can reach considerably higher numbers in the same area. Carnivorous tabanid larvae occasionally bite humans, such as military personnel walking barefoot in rice fields or other areas containing such larvae. These bites can be quite painful.

Deer flies, about 8 to 15 mm long, are about half the size of horse flies, which range from 20 to 25 mm long. The most common tabanid genera containing man-biting species are *Chrysops* (deer flies), and *Tabanus* and *Haematopota* (horse flies). *Chrysops* and *Tabanus* have a worldwide distribution. *Haematopota* species, also known as clegs or stouts, are not found in South America or Australia, and only a few species occur in North America. However, they are common in Europe, Asia, Africa, India and East Asia.

Only female tabanids bite and take a bloodmeal, and nearly all species feed on mammals. Males feed on flower and vegetable juices. Tabanids are diurnal and are most active on warm, sunny days with low wind speeds, especially during the early morning and late afternoon. Adults are powerful flyers with a range of several km. They are very persistent biters, and their painful bites are extremely annoying. They locate their hosts mainly by sight (color and movement), although olfactory stimuli like carbon dioxide and other host odors are involved. Because of their preference for dark objects, they tend to bite through colored clothing rather than light-colored skin. Their large mouthparts enable them to penetrate many types of clothing.

Tabanids lacerate the skin with scissor-like mouthparts and ingest the blood that flows into the wound. Some species can consume as much as 200 mg of blood. The puncture in the skin continues to ooze blood after the fly has fed. Tabanid bites often become secondarily infected, and systemic reactions may occur in hypersensitive individuals. The mouthparts and feeding behavior of tabanids are well suited to the mechanical transmission of blood-borne pathogens, and these flies have been incriminated in the transmission of tularemia. Because their bites are painful, tabanids are frequently disturbed while feeding and move readily from host to host. In East Asia tabanids are not vectors of human disease but are serious pests of livestock and transmit several diseases of veterinary importance.

Tabanids are difficult to control. Larval control is impractical due to the difficulty in locating breeding places. Since larvae of most species live below the surface of the soil, insecticides would not penetrate the soil and vegetation and contact the immature stages. Similar problems are encountered in the control of ceratopogonid larvae. ULV aerosols are generally ineffective against adults. Localized control can be achieved around military encampments using a variety of simple traps. The skin repellent DEET is only moderately effective against these flies.

B. Venomous Snakes of East Asia.

There are 33 species of venomous terrestrial snakes in East Asia and 23 species of venomous sea snakes. Only a relatively small number of these would be commonly encountered and likely to inflict a fatal bite. For a complete list of venomous snakes and their distribution, see Tables 2 and 3. The families of venomous snakes present in the region are Elapidae, Viperidae, Colubridae, and Hydrophiidae. Only the most important snakes from three families will be discussed here.

1. Elapidae.

The king cobra, *Ophiophagus hannah*, is the world's largest venomous snake and is the most feared cobra in the region. It normally reaches a length of 3 m, and occasionally exceeds 5 m. This olive green snake has a yellow throat and can raise its body off the ground up to one-third of its length. It does not have the spreadable hood characteristic of other cobras in the region. The king cobra hunts other snakes, primarily during the day. It inhabits areas with dense undergrowth in jungles, forests, mangrove swamps, and coffee and tea plantations. It also prefers heavy rainfall and is most active during the monsoon season. The female lays 20 to 40 eggs in a nest of dead leaves and twigs and remains coiled around them for 60 to 90 days until the eggs hatch. The young are black and about 0.5 m long when born. The king cobra's neurotoxic venom is not as potent as that of other snakes, but because of its large venom glands it can inject a greater quantity of venom. These glands can contain as much as 6 ml of venom, enough to kill an Asian elephant. Despite its massive size and fierce reputation, the king cobra is not an aggressive snake. Much more deliberate in its actions than the smaller, excitable cobras (*Naja* spp.), it will quickly crawl away if given the opportunity.

Cobras with hoods in East Asia include the monocled cobra, *Naja naja kaouthia*, and the diocellate cobra, *N. n. naja*. These smaller cobras are distinguished by the markings on their hoods. The monocled cobra has a single round spot, called the ocellus, on the hood. These species are less than half the length of the king cobra but are likely to be more excitable. A cobra cannot strike upward, only downward and rather slowly compared to a viper. They usually lay their eggs in rat holes, termite mounds or other sheltered places. They feed on rats and mice at dusk or night.

The kraits are the next most prominent group of elapid snakes. They have a characteristic pattern of hexagonal scales and striking whitish or yellowish bands on the body. They are small snakes (1 to 1.7 m in length) and are usually mostly blue or black in color. The mouth and fangs are small. The shape of the tail ranges from pointed to blunt. Kraits are active at night and hunt other snakes, rodents or lizards. These snakes are generally timid unless disturbed. Their venom is neurotoxic and often fatal but, unlike cobras, there is no swelling or burning at the bite site. The most common snakes in this group are the banded krait, *Bungarus fasciatus*, and the many banded krait, *B. multicinctus*. Of these two species, the bite of *B. multicinctus* is most likely to be fatal.

Coral snakes are closely related to kraits. They are small, slender, and are often brightly colored, with a pinkish coral color on their bellies. The most prominent coral snakes are *Callophis isawakii*, *C. boettgeri*, and *C. macclellandii*. Although their venom is very toxic, they have small mouths and short fangs, requiring them to chew the venom into their prey. They are shy and secretive, so contact with humans is usually rare.

2. Viperidae.

Snakes in the family Viperidae have hinged fangs that are long and tuck into the roof of the mouth when not in use. There are 2 prominent venomous subfamilies in this region, the Viperinae, known as the true vipers, and the Crotalinae, the pit vipers. Unlike other snakes, the pit vipers have a heat-sensing pit located between the eye and the nostril. The pit organs are extremely sensitive to infrared radiation and enable snakes to detect the heat radiating from warm-blooded prey. A third subfamily, Azemiopinae, is represented by just one species, *Azemiops feae*. The venom of this snake has been poorly studied, and its toxicity to man is unknown. *Azemiops feae* is less than 1 m in length and occurs in the southern provinces of China from Xizang east to Jiangxi.

a. Subfamily Viperinae.

Russell's viper, *Daboia russelii*, is the most well known in this group. This snake has a V-shaped marking on its head, pointing toward the front. The head is broad, flat, and triangular. The body averages up to 1.3 m in length but may reach 1.9 m and has three longitudinal rows of reddish-brown spots or rings, though only the dorsal ring is complete. The body color varies from grayish to olive in this region, but the color of the rings is consistent. Russell's viper inhabits open plains, bushy areas, rocky terrain and hills up to 1,000 m, where it hunts lizards, toads, and small mammals at night. It is extremely aggressive during encounters with humans and frequently inflicts fatal wounds. The young are produced viviparously, 20 to 60 at a time. When threatened, this snake produces a strong hissing sound.

b. Subfamily Crotalinae.

This subfamily includes the pit vipers. The head in this subfamily is flat and triangular with a snout that often ends in a hump. Characteristic pits on the head between the eye and the nostril contain heat-detecting sense organs. The tail is short and tapering. These snakes are terrestrial, nocturnal, and aggressive when disturbed.

The Chinese mountain viper, *Ovophis monticola*, is a stocky snake that occurs in mountainous terrain up to 2,600 m. This species is gray to olive, speckled with black, and has squarish brown-red blotches across the back. The average length is about 1 m, with a maximum length of about 1.25 m. This snake is irritable and strikes readily. Females guarding their eggs are especially dangerous.

The sharp-nosed pit viper, *Deinagkistrodon acutus,* is the most dangerous pit viper in East Asia. The snout ends in an upturned pointed appendage with large shields on the crown, giving it its name. The body color is gray or brown with dark brown crossbands that are narrow at the center of the back and wide on the sides. Its length is 1 to 1.25 m, with a maximum of 1.6 m. The sharp-nosed pit viper occurs in rocky, wooded, hilly country. This is a sedentary snake, but it is irritable and easily aroused. It will strike without warning when alarmed.

The mamushi, *Gloydius halys*, and a related species, *G. blomhoffii brevicaudus*, are common in Japan, Korea, and eastern and northern China. The facial pits alone are usually sufficient for identification, but mamushis also possess large crown shields that distinguish them from other pit vipers within their range. Mamushis are yellowish or reddish brown in color, with wide brown crossbands. They resemble the cottonmouth mocassin of the U.S. The average length is 0.5 to 0.6 m, with a maximum of 0.9 m. Mamushis inhabit a wide range of environments from low, marshy river valleys to mountains up to 3,900 m. They are responsible for thousands of bites annually in Japan, although they are generally inoffensive, diurnal snakes. When aroused, mamushis flatten the body and shake their tail. The bite is rarely fatal, and death occurs only in about 1 out of 1,000 cases.

The Asian lance-headed vipers include the Okinawa habu, *Trimeresurus flavoviridis*, and the Chinese habu, *T. mucrosquamatus*, as well as the related species *Ovophis okinavensis* and *T. elegans*. The Okinawa habu is a light olive to brown color with elongated greenish to brownish blotches edged with yellow along the back. The average length is 1.25 to 1.4 m, with a maximum length of 2.25 m. It occurs only on the Amami Islands and Okinawa and inhabits the transition zone between cultivated fields and palm forest, where it hides in rock walls, old tombs, and caves. This is an active, nocturnal snake that frequently enters human dwellings in search of rats or mice. It is aggressive and irritable and strikes rapidly with a long reach. The bites are fatal in only about 3% of cases, although many bites produce disabling wounds. The Chinese habu is grayish brown to olive in color with three rows of darker brown or gray spots with yellow edges across the back, forming a broken wavy stripe. The length is 0.9 to 1 m, reaching a maximum of 1.25 m. The Chinese habu occurs in hilly areas with grass or sparse forests. Its habits and the toxicity of its venom are similar to those of the Okinawa habu.

4. Hydrophiidae.
Sea snakes are all venomous and possess fixed fangs like their close relatives the elapids. Sea snakes must come to the surface to obtain air. The nostrils are located dorsally on the snout and have valves that close to exclude water. Their bodies are laterally compressed, and their paddle-like tails make them excellent swimmers. Sea snakes can dive up to 160 m, although they generally inhabit much shallower water. Sea snakes feed on fish, crustaceans, or other marine life. Hydrophiids are so specialized for sea life that they are virtually helpless on land. They are most numerous during the monsoon season in East Asia. Sea snakes may move into river mouths, as well as along the coast, and are commonly encountered by fishermen, who are

frequently bitten as they remove fish from their nets. However, sea snakes are generally even tempered and will usually avoid swimmers. Their venom is quite toxic, although people are rarely seriously envenomated because the small mouths and short fangs of these snakes make it difficult to inject sufficient venom. Only about 3% of envenomated persons die. Death is caused by toxicity at the neuromuscular junction, resulting in respiratory failure.

The yellow-bellied sea snake, *Pelamis platurus*, is the most widely distributed of the sea snakes, and frequently enters freshwater rivers for extended periods, sometimes for months. It also is found at the surface of the open ocean as it drifts with currents. This snake requires tropical waters where the average monthly temperature is consistently 20°C or more. Unlike most sea snakes, it frequently occurs in large numbers in water slicks along the sea surface where it preys upon fish. This species will often go into a feeding frenzy and bite anything in its surroundings.

The beaded sea snake, *Enhydrina schistosa*, occurs in the South China Sea. This snake is uniformly dull olive green with dark crossbands that tend to fuse anteriorly. It has great flexibility in the lower jaw that enables it to swallow large prey. The average length of adults is 0.9 to 1.25 m, with a maximum size of 1.4 m. The beaded sea snake occurs in shallow waters with mud and sand bottoms and frequently occurs in the channels of large river deltas many miles from open sea. It gives birth to live young in the summer months of June and July, with 4 to 9 young per brood. This snake has a potentially dangerous bite and inflicts more fatal bites in the region than all other sea snake species combined.

Most marine snakes of Asian waters are less than 1 m in length. Stoke's sea snake, *Astrotia stokesii*, occurs in the South China Sea and is unusually large. The average adult is 1.25 to 1.4 m long, and it may reach nearly 2 m in length. It also grows to 0.3 m in girth, which is very large for a sea snake. Stoke's sea snake is light brown or yellow to orange in color, with broad black rings or bars. It inhabits deep, open water and often occurs in large numbers. The effects of its venom have not been well studied.

The annulated sea snake, *Hydrophis cyanocintus,* occurs in both the South and East China Seas. This is a dirty white to pale green or yellow snake with black crossbands that do not always encircle the body. Adults of this species are also large, averaging 1.3 to 1.6 m in length and occasionally reaching 2 m. This snake frequents mangrove swamps but may occur up to 20 miles offshore in winter months. It readily bites if restrained, and natives in the area fear and avoid it. Its venom is one of the most toxic in the region, second only to that of *E. schistosa*.

The distribution of venomous snakes in East Asia appears in Tables 2 and 3. Sources of snake antivenins are listed in Appendix C. For additional information on snakes and snakebite, contact DPMIAC. Also consult: Management of Snakebite in the Field, section IX A, by LTC Hamilton.

Table 2. Distribution of Venomous Terrestrial Snakes in East Asia
(+ = Present; ? = Uncertain)

Species	China	Japan	North Korea	South Korea	Mongolia	Taiwan
COLUBRIDAE						
Rhabdophis subminiatus	+					+
R. tigrinus	+	+	+	+		+
ELAPIDAE						
Bungarus fasciatus	+					
B. m. multicinctus	+					+
B. m. wanghoatingi	**?**					
Calliophis boettgeri	**?**	+				**?**
C. isawakii		+				
C. macclellandii						+
Naja atra	+					+
Naja kaouthia	+					
Ophiophagus hannah	+					
VIPERIDAE						
Azemiops feae	+					
Daboia russelii	+					+
Deinagkistrodon acutus	+					+
Gloydius blomhoffii brevicaudus	+	+	+	+		**?**
G. halys	+	+			+	
G. intermedius	+				+	
G. saxitalis	+		+	+		
G. strauchi	+					

Table 2. Continued

Species	China	Japan	North Korea	South Korea	Mongolia	Taiwan
G. ussuriensis	+		+	+		
Ovophis monticola	+	**?**				+
O. okinavensis		+				
Trimeresurus albolabris	+				+	**?**
T. elegans		+				**?**
T. flavomaculatus		**?**				
T. flavoviridis		+				
T. gracilis	+					+
T. jerdonii	+					
T. mucrosquamatus	+					+
T. stejnegeri	+					+
Tropidolaemus wagleri	**?**					**?**
Vipera berus	+		+		+	
V. ursinii	+				+	

Table 3. Distribution of Sea Snakes in East Asia (+ = Present; ? = Uncertain)

Species	**South China Sea**	**East China and Yellow Seas**
HYDROPHYIIDAE		
Acalyptophis peronii	+	
Aipysurus eydouxi	+	
Astrotia stokesii	+	
Emydocephalus annulatus	+	+
E. ijimae	+	+
Enhydrina schistosa	+	
Hydrophis brookei	+	
H. caerulescens	**?**	
H. cyanocinctus	+	+
H. fasciatus	+	
H. gracilis	+	
H. melanocephalus	+	
H. melanosoma	+	
H. ornatus	+	+
H. parviceps	+	
Lapemis hardwickii	+	+
Laticauda colubrina	+	+
L. laticaudata	+	+
L. semifasciata	+	+
Microcephalophis gracilis	+	
Pelamis platurus	+	+
Praescutata viperina	+	
Thalassophis anomalus	+	

C. Medical Botany.

1. Plants that Cause Contact Dermatitis. Plant dermatitis is a problem of enormous magnitude. Categories of dermal injury caused by plants include mechanical injury, immediate or delayed contact sensitivity, contact urticaria, phototoxicity and photoallergy, primary chemical irritation, or some combination of these. Plants causing contact dermatitis in East Asia are listed in Table 4.

Members of the *Rhus* group (poison ivy, oak, and sumac) are the most frequent causes of acute allergic contact dermatitis. About 70% of the U.S. population is sensitive to urushiol in the sap of these plants. Any part of the skin surface of a sensitized individual may react upon contact with *Rhus* spp. Urushiol remains active for up to 1 year and is easily transferred from an object to a person, so anything that touches poison ivy (clothing, tools, animal fur, sleeping bags) can be contaminated with urushiol and cause dermatitis in a sensitive person who touches the object. Even smoke from burning plants can produce a severe allergic response. Barrier creams have been developed to prevent contact dermatitis in people sensitive to urushiol but are only partially effective. Allergy to poison ivy, oak and sumac may also mean a person is allergic to related plants, including cashews, pistachios, mangos and Chinese or Japanese lacquer trees (*Toxicodendron verniciflua*). A thick viscous sap derived from the bark of the Japanese lacquer tree is used for varnishing furniture and many other objects. Once applied, the lacquer may retain its allergenicity for many years. The ginkgo tree, *Ginkgo biloba*, is native to western China but is widely planted along streets and in gardens. Its fruit contains compounds similar to urushiol that can cause a contact dermatitis resembling poison ivy dermatitis.

Contact urticaria may result from immunological or nonimmunological host responses, although the latter is more common. Nettles, such as *Urtica* spp. and *Laportea* spp., are examples of plants that cause nonimmunological contact urticaria. These plants have hollow stinging hairs that inject a chemical after penetration of the skin. A burning sensation and pruritis occur almost immediately. Urticaria from contact with the hairs of some plants can be severe, persisting for days or even weeks.

A number of cultivated plants of the carrot and rue families sensitize the skin to long-wave ultraviolet light (phytophotodermatitis). Within 6 to 24 hours of contact with the plant and exposure to sunlight or fluorescent light, the area of contact will selectively burn. In some cases, hyperpigmentation may persist for several months. In Japan, several *Heracleum* species contain phototoxic furcocoumarins.

Some plants contain primary chemical irritants that produce skin damage resembling that from contact with a corrosive acid. The reaction depends on the potency of the irritant. The most serious reactions involve the eye. *Daphne* spp. and *Mucuna* spp. are examples of plants

containing chemical irritants. The latex of some *Euphorbia* spp. is highly irritating and may cause blindness if it contacts the eyes.

Mechanical injury by splinters, thorns, spines and sharp leaf edges can produce visual impairment or fungal and bacterial infections at the site of injury. Plant thorns and spines may introduce infective microorganisms, including *Clostridium tetani*, into the skin and sub-cutaneous tissues. Some dried seeds are hygroscopic and can cause severe discomfort due to swelling of the plant tissues when lodged in the auditory canal or other body cavities. Many bulbs and some plants, notably *Dieffenbachia*, the popular house plant known as dumb cane, contain calcium oxalate. This water-insoluble salt forms bundles of needle-like crystals that can cause severe irritation with they become embedded in the skin or mucosae. Plant juice containing calcium oxalate causes severe pain when splashed into the eyes, and large numbers of calcium oxalate crystals may penetrate the cornea.

For additional information on plants causing dermatitis, contact DPMIAC.

Table 4. Plants that Cause Contact Dermatitis in East Asia.

Species	China	Japan	Mongolia	North Korea	South Korea	Taiwan
Abrus precatorius		+	+			+
Aconitum spp.	+	+				
Actaea spp.	+	+		+	+	
Aleurites spp.	+	+				
Ammannia spp.	+					
Argermone spp.	+	+		+	+	+
Campis spp.	+	+		+	+	
Croton spp.	+	+	+	+	+	+
Daphne spp.	+		+	+	+	+
Datura spp.	+	+	+	+	+	+
Dendropanax trifidus		+				
Euphorbia spp.	+	+		+	+	+
Excoecaria spp.						+
Ginkgo biloba	+	+			+	+
Heracleum spp.		+				
Jatropha spp.	+	+	+	+	+	+
Laportea spp.	+		+			+
Mangifera spp.	+					
Mucuna spp.	+					+
Rhus spp. (*Toxicodendron* spp.)	+	+		+	+	
Ricinus communis	+	+				+
Sapium spp.	+	+				
Semecarpus spp.	+					+
Sterculia spp.	+					+
Urtica spp.	+	+	+	+	+	+

2. Systemic Toxicity from Ingestion of Plants. Most wild plants contain toxic components, and military personnel must be instructed not to consume local plants unless necessary for survival. Wild plants are difficult to identify, and poisonous plants can easily be mistaken for plants with parts safe to eat. Military personnel will be forced by necessity to consume wild plants during survival operations. To avoid accidental poisoning, they should be thoroughly trained to recognize common edible plants in the region. Local inhabitants may be knowledgeable about poisonous plants in the area.

The cashew nut, *Anacardium occidentale*, is extremely toxic if eaten uncooked, and the resin in the plant can cause severe dermatitis. The cashew nut shell, but not the kernel, contains a brown oily juice that is a contact allergen. Roasting the shell liberates irritating vapors. In India, where cashews are grown commercially, cashew nut dermatitis often affects thousands of workers. However, cashew nut trees are found in tropical climates and are not widely grown in East Asia.

Many plants have fruiting bodies or have attractive parts that appear edible. *Ricinus communis*, the castor oil plant, has highly ornamental, oval seeds. Castor oil is derived from the seeds. The plant is native to Asia and may be grown commercially in some tropical areas of East Asia. All parts of the plant, especially the seeds, contain ricin, one of the world's most toxic substances. If the beans are swallowed whole, the hard coat prevents absorption and therefore inhibits poisoning, but 2 to 6 beans can be fatal to an adult if well chewed. One or 2 seeds can be fatal to a child. The fruit of the ginkgo tree, *Ginkgo biloba*, contains a nut that has a sweet taste when roasted. However, it is surrounded by a foul-smelling fleshy layer that can cause gastroenteritis if eaten.

Seeds of *Abrus precatorius* (known variously as rosary pea, precatory bean, prayer vine or crab's eye) possess one of the most powerful plant toxins known. One or two seeds, if thoroughly chewed, are capable of killing an adult human. The proteinaceous toxin, abrin, is similar in toxic effects to that of ricin. It is readily absorbed through the digestive tract and causes serious and often fatal clotting in the bloodstream. The attractive seeds are part scarlet-red and part shiny black. They may be used in making rosary necklaces or other costume jewelry in some countries, although this practice is illegal in the U.S.

All species of *Datura*, particularly the jimson weed, *Datura stramonium*, contain belladonna alkaloids. The entire plant is toxic, including the nectar, but berries are involved in most accidental poisonings. Only about 5 grams of leaves or seeds, or just a few berries, can be fatal for a child. *Daphne* spp. are widely planted as ornamentals. The fragrant flowers of these small shrubs bloom in the early spring before the leaves appear. They are among the oldest plants recognized as poisonous. Of all the *Daphne* species, *D. mezereum* is the most deadly.

Some military personnel may be tempted to consume plants because they are used locally for various purposes. Local lore may attribute medicinal qualities, psychotropic or aphrodisiac

effects to native plants. Betel nut, *Areca catechu*, is chewed in many countries of East Asia, especially in rural areas. The plant contains an alkaloid, arecoline, that possesses numerous pharmacological properties. Significant illness can be associated with its use, including asthma exacerbation, cholinergic crisis, cardiac arrhythmias, acute psychosis, milk-alkali syndrome, and oropharyngeal tumors from long-term use. Betel nut may be mixed with other substances, depending on local customs. Medical personnel and combat commanders must be aware that some troops will be tempted to experiment with native plants. Military personnel should not chew on any part of an unfamiliar plant or use unfamiliar plants for fuel or cooking materials.

In most cases of poisoning, care is usually symptom driven. The age and medical condition of the patient influence toxic response and medical treatment. Special monitoring and specific drug therapy are indicated in some instances. Because life-threatening intoxications are rare, military medical personnel may have little experience in management of plant poisoning. It is inappropriate to assume that the toxicity exhibited by a single member of a genus will apply to all other species of that genus or that all toxic members of a genus will have similar effects. Most toxic plants, regardless of their ultimate effects, induce fluid loss through vomiting and diarrhea. This is important when military personnel are operating in hot, arid areas. Plant toxicity varies with the plant part, maturity, growing conditions, and genetic variation.

TG 196, Guide to Poisonous and Toxic Plants, provides information on toxic plants common in the U.S. that also occur in other regions of the world. It includes a list of state and regional poison control centers. For additional information, contact DPMIAC.

Appendix A.1. Vector Ecology Profiles of Malaria Vectors in East Asia.

Species	Larval Habitats	Feeding Behavior	Resting Behavior	Flight Behavior
Anopheles aconitus	Rice fields, stream pools, shaded pools with grasses.	Feeds on man and animals, indoors and outdoors.	Indoors and outdoors.	Moderately strong flier, 1.5-2.5 km.
An. annularis	Rice fields, permanent water with emergent vegetation.	Generally zoophilic, feeding outdoors before midnight.	Outdoors.	Flies up to 1.7 km.
An. campestris	Usually deep, brackish water, ditches, wells with some vegetation and shade.	Often anthropophilic, feeds indoors or outdoors, bites in shaded areas.	Indoors and outdoors.	Moderate range flier.
An. dirus	Isolated stream pools, undisturbed ground pools, cisterns.	Highly anthropophilic, feeds primarily between 2200-0400 hrs indoors and outdoors.	Indoors and outdoors.	Flies 2-4 km.
An. fluviatilis	Stream beds, vegetated ponds, edges of swamps in foothill areas.	Feeds on man and animals during the night until 0300 hrs.	Indoors and outdoors.	Flight range of 0.5-1.5 km.
An. jeyporiensis	Rice fields, seepages, grassy streams, pond edges, and ponds, often with water hyacinths.	Feeds on man and animals, indoors and outdoors.	Indoors and outdoors, often in animal sheds.	Flies 0.8 km or more.
An. lesteri anthropophagus	Clear, shaded pools, edges of lakes or ponds.	Found in foothill areas. Endophagic and endophilic. Feeds readily on man.	Indoors.	Moderately strong flier.

Appendix A.1. Continued

Species	Larval Habitats	Feeding Behavior	Resting Behavior	Flight Behavior
An. kunmingensis	Rice fields, ponds and ditches.	Endophagic and endophilic in mountainous and northern areas. Feeds readily on man.	Indoors.	Moderate flier.
An. maculatus	Stream margins, pond edges, ditches, rice fields with some algae.	Feeds on man and animals, mostly between 1800-2100 hrs.	Rests outdoors after feeding.	Flies up to 1 km.
An. messeae	Shores of lakes or river valleys with emergent vegetation.	Feeds outdoors, primarily on animals.	Outdoors.	Not reported.
An. minimus	Stream margins, ground pools, irrigation ditches and seepages.	Feeds strongly on man, but also on animals, with most feeding occurring early in the evening.	Indoors.	Flies up to several km.
An. nigerrimus	Deep ponds, borrow pits, swamps.	Feeds on man and animals outdoors, early in the evening or sometimes after dawn.	Outdoors.	Unknown flight range.
An. philippinensis	Rice fields, sunlit water with submerged vegetation.	Primarily zoophilic, feeding primarily outdoors.	Primarily outdoors.	Weak flier, < 0.8 km.
An. pseudowillmori	Stream margins, pond edges, ditches, rice fields with some vegetation.	Feeds on animals and man, primarily from 1800-2100 hrs.	Outdoors.	Flies up to 1 km.
An. sinensis	Rice fields, grassy ponds, along edges of slow-moving streams. Resistant to pollution.	Primarily zoophilic. Occurs in very large numbers in rice growing regions.	Usually outdoors, or in animal sheds.	Moderately strong flier.
An. yatsushiroensis	Swampy habitats with emergent vegetation.	Primarily zoophilic, feeding outdoors.	Rests outdoors or in animal shelters.	Moderately strong flier.

Appendix A.2. Vector Ecology Profiles of Common Tick Vectors in East Asia.

Species	Geographic Distribution	Potential Hosts	Disease Transmission	Bionomics/Habitat Information
Dermacentor nuttalli	Xinjiang Province in China, Inner Mongolia.	Immatures: field mice, voles, badgers, rabbits, ground squirrels. Adults: sheep, cattle, humans.	Boutonneuse fever.	Inhabits edges of forests, roadside grassy areas. Adults emerge after spring snow melt, peaking in April. Life cycle similar to *D. silvarum*.
D. silvarum	Northeastern and northwestern China, Mongolia.	Immatures: small rodents, hares, shrews, foxes. Adults: sheep, dogs, deer, cattle, humans.	Boutonneuse fever. Transovarial transmission occurs.	Inhabits taiga forests. Life cycle may take 2-3 years. Adults are resistant to desiccation. Females may diapause on hosts. Females lay 1000's of eggs.
Haemaphysalis concinna	Northeastern and northwestern China, upper half of Mongolia, mainland Japan, Hokkaido, and Korea.	Immatures: hares, hedgehogs, voles. Adults: cattle, dogs, sheep, deer.	Boutonneuse fever. Transstadial and transovarial transmission occur.	Inhabits meadows, clearings of birch and aspen. Nymphs overwinter and adults emerge in spring. Females may lay 1000's of eggs. Life cycle requires 1-3 years.
H. flava	Japan.	Immatures: hares, field mice. Adults: sika deer.	Potential vector of TBE, Lyme disease and tularemia.	Inhabits montane regions. Nymphs peak in August-September. Adults peak in November-December. Resists desiccation. Adults overwinter.

Appendix A.2. Continued

Species	Geographic Distribution	Potential Hosts	Disease Transmission	Bionomics/Habitat Information
H. longicornis	China, Mongolia, Japan, Korea.	Immatures: cattle, deer. Adults: cattle, deer.	Lyme disease.	Three-host tick. Adults may be parthenogenetic in northern part of their range. Females deposit 1000-3000 eggs. Nymphs or adults overwinter. Life cycle may require several years.
Hyalomma asiaticum	Northern and northwestern China, Mongolia.	Immatures: gerbils, hares, hedgehogs, shrews, birds. Adults: cattle, sheep, and deer.	Vector of CCHF. Transovarial transmission occurs.	Large 3-host tick. Larvae may molt while attached to host. Adults quest over wide areas. Very resistant to desiccation. Often deposit over 10,000 eggs. Life cycle is 2-3 years. Nymphs or adults overwinter.
Ixodes granulatus	Korean Peninsula, China, Japan	Immatures: small rodents. Adults: rodents	A zoonotic vector of Lyme disease.	Life cycle similar to other *Ixodes* spp. Generally inhabits low-lying forests with high rainfall.
I. nipponensis	Japan, China.	Immatures: small rodents, birds, reptiles. Adults: horses, dogs, badgers, beavers, cattle, humans.	Lyme disease.	Inhabits montane regions. Not resistant to severe desiccation.

Appendix A.2. Continued

Species	Geographic Distribution	Potential Hosts	Disease Transmission	Bionomics/Habitat Information
I. ovatus	Japan.	Immatures: hares, other small mammals. Adults: sika deer, humans.	Lyme disease.	Inhabits montane zones. Adults common from spring to autumn.
I. persulcatus	Mongolia, Manchuria, Xinjiang Province in China, Japan, Korea, Taiwan.	Immatures: rodents, shrews, birds. Adults: rabbits, deer, dogs, bear, goats, humans.	Lyme disease, TBE. Transovarial and transstadial transmission occur.	Active months: adults May-July, nymphs in summer, larvae June and September. Nymphs overwinter. Adults lay 1000's of eggs. Larvae spread by host birds. Life cycle takes 2-4 years.
Ornithodoros tholozani	Xinjiang, Qinghai Provinces in China.	Immatures: birds. Adults: sheep, domestic animals, rarely humans.	Tick-borne relapsing fever.	Occurs in caves, huts, stables, rock outcroppings. Larvae do not feed. Nymphs and adults feed rapidly, within 1 hour. Life cycle may take two years to complete. Adults lay 100's of eggs after each bloodmeal.
Rhipicephalus sanguineus	Throughout East Asia.	Immatures: dogs, cattle, horse, sheep, sometimes man. Adults: same as immatures.	Boutonneuse fever.	A 3-host tick. Adults attach in the ears or between toes of dogs. Immatures prefer long hair at the back of the neck. Females crawl upward and lay eggs in cracks of walls or ceilings of houses.

IX. Selected References.

A. Military Publications*

1966. Poisonous snakes of the world, a manual for use by U.S. amphibious forces. NAVMED P-5099, BUMED, Department of the Navy, U.S. Gov. Print. Off., 212 pp.

1987. Technical Information Memorandum (TIM) 23. A concise guide for the detection, prevention and control of schistosomiasis in the uniformed services. AFPMB, 40 pp.

1991. Technical Guide (TG) 138. Guide to commensal rodent control. USAEHA, 91 pp.

1991. Venomous snakes of the Middle East. AFMIC, Fort Detrick, MD. DST-1810S-469-91, 168 pp.

1992. TG 189. Procedures for the diagnostic dose resistance test kits for mosquitoes, body lice, and beetle pests of stored products. USAEHA, 39 pp.

1993. TIM 31. Contingency retrograde washdowns: cleaning and inspection procedures. AFPMB, 8 pp., Appendices A-H.

1994. TG 196. Guide to poisonous and toxic plants. USAEHA, 70 pp.

1995. TG 103. Prevention and control of plague. USACHPPM, 100 pp.

1995. TIM 40. Methods for trapping and sampling small mammals for virologic testing. AFPMB, 61 pp.

1995. Management of snakebite in the field. (unpublished document compiled by LTC Hamilton, filed as DPMIAC 162252).

1998. TIM 26. Tick-borne diseases: vector surveillance and control. AFPMB, 53 pp., Appendices A-J.

1998. Navy Medical Department Pocket Guide to Malaria Prevention and Control. 2nd ed. Technical Manual NEHC- TM6250.98-2.

1999. TIM 41. Protection from rodent-borne diseases. AFPMB, 59 pp., Appendices A-E.

1999. TIM 13. Ultra low volume dispersal of insecticides by ground equipment. AFPMB, 20 pp.

2000. TIM 24. Contingency pest management guide. 6th ed., AFPMB, 122 pp.

2001. TIM 36. Personal protective techniques against insects and other arthropods of military significance. AFPMB, 43 pp., 4 Appendices, Glossary.

2001. TIM 6. Delousing procedures for the control of louse-borne disease during contingency operations. AFPMB, 17 pp.

* TIMs can be downloaded from the AFPMB website.

B. Other Publications

Adiachi, M., S. Nakajima, Y. Morimoto, N. Okajima, Y. Ueda, K. Yamakawa, J. Ebina, K. Matsuno and S. Furui. 1997. Trombiculid fauna and tsutsugamushi disease in Kyoto Prefecture. Med. Entomol. Zool. 48: 97-107.

Ai, C.X., G.C. Qiu, Z.X. Shi, X.M. Wu, X.D. Liu and J.H. Zhao. 1991. Host associations and seasonal abundance of immature *Ixodes persulcatus* (Acari: Ixodidae) in a Lyme disease endemic area of China. Exp. Appl. Acarol. 12: 251-257.

Akuzawa, M., A. Oishi, S. Fushuku, E. Deguchi, K. Misumi, H. Sakamoto and K. Okamoto. 1999. [Survey of *Leptospira* antibodies in dogs in 6 regions of Japan.] J. Japan. Vet. Med. Assoc. 12: 780-783.

Baik, D.H. and C.Y. Joo. 1991. Epidemio-entomological survey of Japanese encephalitis in Korea. Korean J. Parasitol. 29: 67-95.

Beaty, B.J. and W.C. Marquardt (eds.). 1996. The biology of disease vectors. University of Colorado Press. Niwot, CO.

Berg, S.W., B.S. Mitchell, R.K. Hanson, R.P. Olafoson, R.P. Williams, J.E. Tueller, R.J. Burton, D.M. Novak, T.F. Tsai and F.S. Wignall. 1997. Systemic reactions in U.S. Marine Corps personnel who received Japanese encephalitis vaccine. Clin. Infect. Dis. 24: 265-266.

Brogdon W.G. and J.C. McAllister. 1998. Insecticide resistance and vector control. Emerg. Infect. Dis. 4: 605-613.

Bruce-Chwatt, L.J. 1985. Essential malariology, 2nd ed. John Wiley and Sons, New York.

Cao, W.C., Y.M. Gao, P.H. Zhang, X.T. Zhang, Q.H. Dai, J.S. Dumler, L.Q. Fanb and H. Yang. 2000. Identification of *Ehrlichia chaffeensis* by nested PCR in ticks from southern China. J. Clin. Microbiol. 38: 2778-2780.

Chai, J.Y. 1999. Re-emerging *Plasmodium vivax* malaria in the Republic of Korea. Korean J. Parasitol. 37: 129-143.

Chang, W.H., M.S. Kee, S.H. Kee, I.S. Kim, C.S. Park, I.J. Kim, K.W. Choi, J.H. Woo and J. S. Kang. 1990. [Seroepidemiological survey of tsutsugamushi disease in Korea, 1989.] J. Korean Soc. Microbiol. 25: 227-235.

Chen, D. and H. Pan. 1999. [Demonstration for periodicity of leptospirosis in Yichang City of Hubei Province during 1960-1997.] Chung Hua Liu Hsing Ping Hsueh Tsa Chih 20: 218-219.

Chen, H.L., H.Y. Chen and C.B. Horng. 1993. [Surveillance of scrub typhus in Taiwan.] Chin. J. Microbiol. Immunol. 26: 166-170.

Chen, H.L., J.Y. Yang, H.Y. Chen, T.H. Lin, G.R. Wang and C.B. Horng. 1998. Surveillance of anti-hantavirus antibodies among certain high-risk groups in Taiwan. J. Formos. Med. Assoc. 97: 69-72.

Chen, H.X. and F.X. Qiu. 1993. Epidemiologic surveillance on the hemorrhagic fever with renal syndrome in China. Chin. Med. J. 106: 857-863.

Chen, H.X. and F.X. Qiu. 1994. Studies on the environment structure of natural nidi and epidemic areas of hemorrhagic fever with renal syndrome in China. Chin. Med. J. 107: 107-112.

Chen, H.X., F.X. Qiu, B.J. Dong, S.Z. Ji, Y.T. Li, Y. Wang, H.M. Wang, G.F. Zuo, X.X. Tao and S.Y. Gao. 1986. Epidemiological studies on hemorrhagic fever with renal syndrome in China. J. Infect. Dis. 154: 394-398.

Chen, M., M.Y. Fan, D.Z. Bi, Z.J. Zhang and Y.P. Huang. 1998. Detection of *Rickettsia sibirica* in ticks and small mammals collected in three different regions in China. Acta Virol. 42: 61-64.

Chen, W.J., S.L. Chen, L.J. Chien, C.C. King, M.R. Harn, K.P. Hwang and J.H. Fang. 1996. Silent transmission of the dengue virus in southern Taiwan. Am. J. Trop. Med. Hyg. 55: 12-16.

Chen, Y.R., J.S. Hwang and Y.J. Guo. 1994. Ecology and control of dengue vector mosquitoes in Taiwan. Kao Hsiung I Hsueh Ko Hsueh Tsa Chih 10 Suppl: 78-87.

Chin, C., T.S. Church, W.C. Yang, T.H. Yang, C.M. Shih, H.T. Lin, K.C. Lin, J.C. Lien, T.F. Tsai, S.L. Ruo, S.T. Nichol, T.G. Ksiazek, P.E. Rollin, C.J. Peters, T.N. Wu and C.Y. Shen. 2000. Hantavirus infection in Taiwan: the experience of a geographically unique area. J. Med. Virol. 60: 237-247.

Chin, J. 2000. Control of communicable diseases manual, 17th ed. American Public Health Association, Washington, DC. (US Army FM 8-33, US Navy P-5038).

Cho, B.K., H. Kang, D. Bang, S.N. Kim, S. Hwang and E.S. Song. 1994. Tick bites in Korea. Int. J. Dermatol. 33: 552-555.

Cho, M.K., S.H. Kee, H.J. Song, K.H. Kim, K.J. Song, L.J. Baek, H.H. Kim, H.B. Oh, Y.W. Kim and W.H. Chang. 1998. Infection rate of *Leptospira interrogans* in the field rodent, *Apodemus agrarius*, in Korea. Epidemiol. Infect. 121: 685-690.

Choi, C.S. and K.S. Shin. 1996. Zoonotic infections caused by microorganisms to be originated from animals or their ectoparasites in Korea. J. Korean Soc. Microbiol. 31: 235-271.

Chow, C.Y. 1973. Arthropods of public health importance in Korea. Korean J. Entomol. 3: 31-54.

Chuang, C.H. 1991. Current status of malaria in Taiwan from 1966 to 1990. Kao Hsiung I Hsueh Ko Hsueh Tsa Chih 7: 233-242.

Chuang, Y.Y., C.S. Lin, C.H. Wang and C.C. Yeh. 2000. Distribution and seasonal occurrence of *Forcipomyia taiwana* (Diptera: Ceratopogonidae) in the Nantou area in Taiwan. J. Med. Entomol. 37: 205-209.

Claborn, D. 1995. Abundance of three mosquito vectors in Okinawa with relevance to disease risk. Mil. Med. 4: 172-173.

Corwin, A., A. Ryan, W. Bloys, R. Thomas, B. Deniega and D. Watts. 1990. A waterborne outbreak of leptospirosis among United States military personnel in Okinawa, Japan. Int. J. Epidemiol. 19: 743-748.

Cross, J.H., G. Zaraspe, S.K. Lu, K.M. Chiu and H.K. Hung. 1984. Susceptibility of *Oncomelania hupensis* subspecies to infection with geographic strains of *Schistosoma japonicum*. Southeast Asian J. Trop. Med. Public Health 15:155-160.

Crump, A. 1989. The perils of water-resource development: Japanese encephalitis. Parasitol. Today 5: 343-344.

Dai, B. 1992. Advances in research on leptospirosis in China. Chin. Med. Sci. J. 7: 239-243.

Dapeng, L., S. Leyuan, L. Xili and Y. Xiance. 1996. A successful programme for falciparum malaria in Xinyang, China. Trans R. Soc. Trop. Med. Hyg. 90: 100-102.

Defraites, R.F., J.M. Gambel, C.H. Hoke Jr, J.L. Sanchez, B.G. Withers, N. Karabatsos, R.E. Shope, S. Tirrell, I. Yoshida, M. Takagi, C.K. Meschievitz and T.F. Tsai. 1999. Japanese encephalitis vaccine (inactivated, BIKEN) in U.S. soldiers: immunogenicity and safety of vaccine in two dosing regimens. Am. J. Trop. Med. Hyg. 61: 288-293.

Dong, X.Q. 1994. [Study on the category of plasmid DNA and molecular epidemiology of *Yersinia pestis* isolated from Yunnan natural plague foci.] Endem. Dis. Bull. 9: 58-63.

Dong, X.S., X.Z. Wang, G.C. Zhang and Y.R. Lu. 1990. Studies on geographical distribution, ecology and habits, role in malaria transmission and control methods for *Anopheles kunmingensis*. Zool. Res. 11: 317-323.

Easton, E.R. 1994. Urbanization and its effect on the ecology of mosquitoes in Macau, Southeast Asia. J. Am. Mosq. Control Assoc. 10: 540-544.

Ebisawa, I. 1995. Current epidemiology and treatment of tsutsugamushi disease in Japan. J. Travel Med. 2: 218-220.

Ejercito, C.L., L. Cai, K.K. Htwe, M. Taki, Y. Inoshima, T. Kondo, C. Kano. S. Abe, K. Shirota and T. Sugimoto. 1993. Serological evidence of *Coxiella burnetii* in wild animals in Japan. J. Wildl. Dis. 29: 481-484.

Eshita, Y. 1982. Japanese references to studies on dengue fever and its vectors. Jap. J. Sanit. Zool. 33: 77-94.

Eshita, Y., T. Huriahara, T. Ogata and A. Oya. 1981. [Studies on the susceptibility of mosquitoes to dengue virus.] Jap. J. Sanit. Zool. 33: 61-64.

Fan, M.Y., D.H. Walker, S.R. Yu, and Q.H. Liu. 1987. Epidemiology and ecology of rickettsial diseases in the People's Republic of China. Rev. Infect. Dis. 9: 823-840.

Fan, P.C. 1990. Filariasis eradication on Kinmen proper, Kinmen (Quemoy) Islands, Republic of China. Acta Trop. 47: 161-169.

Fan, W.F., S.R. Yu and T.M. Cosgriff. 1989. The reemergence of dengue in China. Rev. Infect. Dis. Suppl. 4: 47-53.

Goddard, J. 1996. Physicians guide to arthropods of medical importance, 2nd ed. CRC Press, Inc., Boca Raton, FL.

Grogl, M., J.L. Daugirda, D.L. Hoover, A.J. Magil and J.D. Berman. 1993. Survivability and infectivity of viscerotropic *Leishmania tropica* from Operation Desert Storm participants in human blood products maintained under blood bank conditions. Am. J. Trop. Med. Hyg. 49: 308-315.

Guan, L.R. 1991. Current status of kala-azar and vector control in China. Bull. W HO 69: 595-601.

Guan, L.R., Y.Q. Yang, J.Q. Qu and W.X. Shen. 1995. Discovery and study of *Leishmania turanica* for the first time in China. Bull. WHO 73: 667-672.

Guo, X.G., Z.D. Gong, T.J. Qian, X.G. Feng, X.D. Duan, W. Li and X.K. Zhang. 1999. Host-specificity and host selection of fleas in foci of human plague in Yunnan, China. Entomol. Sin. 6: 370-377.

Harn, M.R., Y.L. Chiang, M.J. Tian, Y.H. Chang and Y.C. Ko. 1993. [The 1991 dengue epidemic in Kaohsiung City.] J. Formos. Med. Assoc. Suppl. 1: 39-43.

Harwood, R.F. and M.T. James. 1979. Entomology in human and animal health, 7th ed. MacMillan Publishing Company, Inc., New York.

Hasegawa H., M. Otsuru and T. Fujii. 1990. Surveys on vector mites of tsutsugamushi disease in Taiwan and the Ryukyu Islands. Jap. J. Sanit. Zool. 41: 235-246.

Hatsushika, R. 1998. [Human cases of infestation with hard tick, *Ixodes ovatus* (Acarina: Ixodidae) in Japan - a bibliographical review.] Med. Entomol. Zool. 49: 1-13.

Hawley, W.A. 1988. The biology of *Aedes albopictus*. J. Am. Mosq. Control Assoc. Suppl. No. 1. pp 1-40.

He, L.Y. 1999. The present status and prospect of tropical medicine in China. Chinese Med. J. 112: 675-676.

Heap, B.J. 1991. Scrub typhus in Hong Kong. J. Trop. Med. Hyg. 94: 97-101.

Hirai, K. and H. To. 1998. Advances in the understanding of *Coxiella burnetti* in Japan. J. Vet. Med. Sci. 60: 781-790.

Ho, C.L., W.C. Chen and Y.L. Lin. 1998. Structures and biological activities of new wasp venom peptides isolated from the black-bellied hornet (*Vespa basalis*) venom. Toxicon 36: 609-617.

Ho, C.L. and L.L. Hwang. 1991. Local edema induced by the black-bellied hornet (*Vespa basalis*) venom and its components. Toxicon 29: 1033-1042.

Ho, C.L., Y.L. Lin and S.F. Li. 1999. Three toxins with phospholipase activity isolated from the yellow-legged hornet (*Vespa verutina*) venom. Toxicon 37: 1015-1024.

Ho, M. 1998. Current outlook of infectious diseases in Taiwan. J. Microbiol. Immunol. Infect. 31: 73-83.

Ho, T., K.K. Htwe, N. Yamasaki, G.Q. Zhang, M. Ogawa, T. Yamaguchi, H. Fukushi and H. Hirai. 1995. Isolation of *Coxiella burnetti* from dairy cattle and ticks, and some characteristics of the isolates in Japan. Microbiol. Immunnol. 39: 663-671.

Hoke, C. and J. Gingrich. 1994. Japanese encephalitis, pp. 59-69. *In*: G. Bergan (ed.) Handbook of Zoonoses, Section B: Viral. CRC Press, Boca Raton, FL.

Hoogstraal, H. 1979. The epidemiology of Crimean-Congo hemorrhagic fever in Asia, Europe, and Africa. J. Med. Entomol. 15: 307-417.

Hoogstraal, H. 1981. Changing patterns of tickborne diseases in modern society. pp. 75-100 *In*: Annual Review of Entomology, Vol. 26, Annual Reviews, Inc., Palo Alto, CA.

Hotez, P.J., F. Zheng, X.L. Qi, C.M. Gang, X.S. Hua, L.S. Xian, D. Blair, D.P. McManus and G.M. Davis. 1997. Emerging and reemerging helminthiases and the public health of China. Emerg. Infect. Dis. 3: 303-310.

Huang, D.Z. 1991. Dendrolimiasis: an analysis of 58 cases. J. Trop. Med. Hyg. 94: 79-87.

Hwang, J.S. and J.T. Chao. 1991. Ecology of *Aedes* mosquitoes and their relationship with dengue epidemics in Taiwan. Chin. J. Entomol. Spec. Publ. No. 6, 105-127.

Ishiguro, F., N. Takada, T. Masuzawa and T. Fukui. 2000. Prevalence of Lyme disease *Borrelia* spp. in ticks from migratory birds on the Japanese Mainland. Appl. Environ. Microbiol. 66: 982-986.

Ishiguro, F., N. Takada, Y. Yano, M. Harada, T. Masuzawa and H. Iida. 1995. Prevalence of antibodies to *Borrelia* spirochetes among wild rodents in central and western Japan. Microbiol. Immunol. 39: 419-424.

Itokawa, H., R. Kano and T. Nakajima. 1985. Examination of the pain producing amines in the venomous hairs or spines of Japanese urticating caterpillars. Jap. J. Sanit. Zool. 36: 83-86.

Iwasa, M., S. Kasuya and S. Noda. 1990. Trombiculid mites (Acari: Trombiculidae) and *Rickettsia tsutsugamushi* isolated from wild rodents in a new endemic area of Japan. J. Med. Entomol. 27: 501-508.

Jo, E.J., J.W. Song, L.J. Baek and H.W. Lee. 1990. [Seroepidemiologic study on the reservoir animals of the etiologic agents of acute hemorrhagic diseases (hemorrhagic fever with renal syndrome, scrub typhus and leptospirosis).] Korea Univ. Med. J. 27: 115-126.

Kamimura, K. 1998. Studies on the population dynamics of the principal vector mosquito of Japanese encephalitis. Med. Entomol. Zool. 49: 181-185.

Kao, C.L., C.J. Chen, T.S. Yen, J.C. Lien and C.S. Yang. 1996. Seroepidemiology of *Hantaan* virus infection in Taiwan. J. Med. Virol. 50: 309-313.

Kariwa, H., S. Yoshizumi, J. Arikawa, K. Yoshimatsu, K. Takahashi, I. Takashima and N. Hashimoto. 1995. Evidence for the existence of Puumala-related virus among *Clethrionomys rufocanus* in Hokkaido, Japan. Am. J. Trop. Med. Hyg. 53: 222-227.

Kawahara, M., T. Ito, C. Suto, S. Shibata, Y. Rikihisa, K. Hata and K. Hirai. 1999. Comparison of *Ehrlichia muris* strains isolated from wild mice and ticks and serology of humans and animals with *E. muris* as antigen. J. Clin. Microbiol. 37: 123-129.

Kawamura, A. and H. Tanaka. 1988. Rickettsiosis in Japan. Jap. J. Exp. Med. 58: 169-184.

Kettle, D.S. (ed.). 1995. Medical and veterinary entomology, 2nd ed. CAB International, University Press, Cambridge, UK.

Kim, D.C. 1985. Brugian filariasis in Korea. Yonsei Reports Trop. Med. 16: 19-27.

Kim, J.S., W.Y. Lee and S.L. Chun. 1973. Ecology of filariasis on Che Ju Island. Korean J. Parasitol. 11: 33-53.

Kitazawa, T. 1993. Fauna and seasonal fluctuation of larval trombiculid mites in northern Kyushu, Japan. Jap. J. Sanit. Zool. 44: 327-334.

Kitazawa, T. 1999. Fauna and distribution of trombiculid mites in relation to the vegetational and geographical environment in northern Kyushu, Japan. Med. Entomol. Zool. 50: 105-127.

Ko, W.C., C.C. Liang, H.Y. Chen and Y.C. Chuang. 2000. Seroprevalence of *Coxiella burnetii* infection in southern Taiwan. J. Formos. Med. Assoc. 99: 33-38.

Ko, Y.C. 1989. [Epidemiology of dengue fever in Taiwan.] Kao Hsiung I Hsueh Ko Hsueh Tsa Chih 5: 1-11.

Kurane, I., T. Takaski and K. Yamada. 2000. Trends in flavivirus infections in Japan. Emerg. Infect. Dis. 6: 569-571.

Lacey, L.A. and C.M. Lacey. 1990. The medical importance of riceland mosquitoes and their control using alternatives to chemical insecticides. J. Am. Mosq. Control Assoc., Suppl. No. 2, pp. 1-93.

Laird, M. 1988. The natural history of larval mosquito habitats. Academic Press, New York.

Lane, R.P. and R.W. Crosskey (eds.). 1993. Medical insects and arachnids. Chapman and Hall, London, UK.

Lawyer, P.G. and P.V. Perkins. 2000. Leishmaniasis and trypanosomiasis. Chapter 8 *In*: Medical Entomology. B.F. Eldridge and J.D. Edman (eds.).

Lee, H.I., D.W. Choi, D.H. Baik and C.Y. Joo. 1986. Epidemiological studies on Malayan filariasis in an inland area in Kyungpook, Korea. Korean J. Parasitol. 24: 15-24.

Lee, H.W. 1989. Hemorrhagic fever with renal syndrome in Korea. Rev. Infect. Dis. 4: S464-S476.

Lee, H.W. and G. Van Der Groen. 1989. Hemorrhagic fever with renal syndrome. Prog. Med. Virol. 36: 62-102.

Lee, I.Y., H.I. Ree and H.K. Hong. 1993. Seasonal prevalence and geographical distribution of trombiculid mites (Acarina: Trombiculidae) in Korea. Korean J. Zool. 36: 408-415.

Lee, J.S. and H.K. Hong. 1995. [Seasonal prevalence and behaviour of *Aedes togoi*.] Korean J. Parasitol. 33: 19-26.

Lee, S.H., B.J. Kim, J.H. Kim, K.H. Park, S.J. Yeo, S.J. Kim and Y.H. Kook. 2000. Characterization of *Borrelia burgdorferi* strains isolated from Korea by 16S rDNA sequence analysis and PCR-RFLP analysis of rrf (5S)-rrl (23S) intergenic spacer amplicons. Int. J. Syst. Evol. Microbiol. 50: 857-863.

Lee, W.K. and B.K. Cho. 1995. [Taxonomic approach to scabies mites of humans and animals and their prevalence in Korea.] Korean J. Parasitol. 33: 85-94.

Lei, C.X. and D.Q. Dong. 1997. Study on the plague natural foci in Yunnan Province. Endem. Dis. Bull. 12: 37-49.

Li, Y., A.C. Sleigh, A.C. Ross, G.M. Williams, M. Tanner and D.P. McManus. 2000. Epidemiology of *Schistosoma japonicum* in China: morbidity and strategies for control in the Dongting lake region. Int. J. Parasitol. 30: 273-281.

Li, Y., A.C. Sleigh, G.M. Williams, A.G. Ross, S.J. Forsyth, M. Tanner and D.P. McManus. 2000. Measuring exposure to *Schistosoma japonicum* in China. III. Activity diaries, snail and human infection, transmission ecology and options for control. Acta Trop. 75: 279-289.

Li, Y.L., S.L. Ruo, Z. Tong, Q.R. Ma, Z.L. Liu, K.L. Ye, Z.Y. Zhu, J.B. McCormich, S.P. Fisher-Hoch and Z.Y. Zhu. 1995. A serotypic study of hemorrhagic fever with renal syndrome in rural China. Am. J. Trop. Med. Hyg. 52: 247-251.

Liang, K.C. 1991. Historical review of malaria control program in Taiwan. Kao Hsiung I Hsueh Ko Hsueh Tsa Chih 7: 271-277.

Lien, J.C. 1991. Anopheline mosquitoes and malaria parasites in Taiwan. Kaohsiung Med. J. 7: 207-223.

Lin, T.J., C.C. Yang, G.Y. Yang, J. Ger, W.J. Tsai and J.F. Deng. 1995. Features of centipede bites in Taiwan. Trop. Geogr. Med. 47: 300-302.

Linthicum, K.J. and C.L. Bailey. 1994. Ecology of Crimean-Congo hemorrhagic fever, pp. 392-437. *In*: Ecological Dynamics of Tick-borne Zoonoses, D. E. Sonenshine and T.N. Mather (eds). Oxford University Press.

Liu, J.Y. and X.M. Li. 1992. [The vectorial position and effect of *Nosopsyllus laeviceps kuzenkovi* in the natural plague foci of the gerbil.] Endem. Dis. Bull. 7: 40-44.

Liu, J.Y., X.J. Liu, Z. Chen, Z.P. Tu, G.B. Zheng, Y.Z. Zhang, S.P. Weng, X.H. Huang and F.Z. Yang. 1991. Filariasis and its control in Fujian, China. Southeast Asian J. Trop. Med. Public Health 22: 147-154.

Liu, Q.H., G.Y. Chen, Y. Jin, M. Te, L.C. Niu, S.P. Dong and D.H. Walker. 1995. Evidence for a high prevalence of spotted fever group rickettsial infections in diverse ecological zones of Inner Mongolia. Epidemiol. Infect. 115: 177-183.

Liu, X.J. and J.G. Liu. 1985. Comparative studies on the capability of transmission of Malayan filariasis between *Anopheles lesteri anthropophagus* and *Anopheles sinensis.* Wuyi Sci. J. 12: 139-142.

Liu, Y.X., Z.Q. Yang, Q.Y. Wu, H.L. Sun, X.R. Meng, Z.L. Peng and Z.S. Miao. 1999. Isolation of *Rickettsia tsutsugamushi* from trombiculid mites (Acari: Trombiculidae) in Feixian County, Shandong Province, China. Entomol. Sin. 6: 171-177.

Lovell, C. R. (ed.). 1993. Plants and the skin. Blackwell Scientific Publications, Oxford.

Ma, H.B., K. Sugiyama, S. Morikawa, M. Mizushima, J. Kobayashi, M. Yamamoto, T. Yamada, Y. Hayashi, M. Shinagawa and H. Senzaki. 1995. Hantavirus infection among *Rattus norvegicus* in Japan. Jpn. J. Med. Sci. Biol. 48: 71-78.

Mahara, F. 1997. Japanese spotted fever: reported cases and review of the literature. Emerg. Infect. Dis. 3: 105-111.

Masuzawa, T. 1997. [Present status of Lyme borreliosis and characterization of Lyme disease *Borrelia* isolated in Japan.] Yakugaku Zasshi 117: 319-338.

Masuzawa, T., T. Komikado, A. Iwaki, H. Suzuki, K. Kaneda and Y. Yanagihara. 1996. Characterization of *Borrelia* sp. isolated from *Ixodes tanuki*, *I. turdus,* and *I. columnae* in Japan by restriction fragment length polymorphism of rrf (5S)-rrl (23S) intergenic spacer amplicons. FEMS Microbiol. Lett. 142: 77-83.

Maszle, D.R., P.G. Whitehead, R.C. Johnson and R.C. Spear. 1998. Hydrological studies of schistosomiasis transport in Sichuan Province, China. Sci. Total Environ. 216: 193-203.

Matsunaga, Y., S. Yabe, K. Taniguchi, M. Nakayama and I. Kurane. 1999. [Current status of Japanese encephalitis in Japan.] Kansenshogaku Zasshi 73: 97-103.

Matsuse, I.T., C.M. Takeda, K. Kamimura and M. Yoshida. 1997. Tolerance of *Latrodectus hasseltii* (Araneae: Theridiidae) to low temperatures in Japan. Med. Entomol. Zool. 48: 117-122.

Matsuzaki, S. 1990. Population dynamics of *Culex tritaeniorhynchus* in relation to the epidemics of Japanese encephalitis in Kochi Prefecture, Japan. Jap. J. Sanit. Zool. 41: 247-255.

Mills, J.N., J.E. Childs, T.G. Ksiazek, C.J. Peters and W.M. Velleca. 1995. Methods for trapping and sampling small mammals for virological testing. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Atlanta, GA.

Min, J.G. and M. Xue. 1996. Progress in studies on the overwintering of the mosquito *Culex tritaeniorhynchus*. Southeast Asian J. Trop. Med. Public Health 27: 810-817.

Minter, D.M. 1989. The leishmaniases. WHO/VBC/89.967 pp. 93-106.

Miyagi, I., T. Toma, W.L. Malenganisho and M. Uza. 1996. Historical review of mosquito control as a component of malaria eradication program in the Ryukyu Archipelago. Southeast Asian J. Trop. Med. Public Health 27: 498-511.

Miyamoto, K. and M. Nakao. 1991. Frequent occurrence of human tick bites and monthly fluctuations of ixodid ticks in Hokkaido, Japan. Jap. J. Sanit. Zool. 42: 267-269.

Mohri, S., A. Sugiyama and K. Saito. 1991. Centipede bites in Japan. Cutis 47: 189-190.

Monath, T.P. (ed.). 1988/89. The arboviruses: epidemiology and ecology. Volumes I-V, CRC Press, Boca Raton, FL.

Nakamura, H., M. Yoshida, A. Kimura, T. Yumisashi, T. Kimura, N. Ueba and N. Kunita. 1999. Ecological studies on Japanese encephalitis in Osaka Prefecture. 5. Abundance and infection with the virus in *Culex tritaeniorhynchus* in relation to environmental conditions for mosquito breeding. Med. Entomol. Zool. 50: 275-286.

Nakamura, H., M. Yoshida, A. Kimura and T. Yumisashi. 1999. [Ecological studies on Japanese encephalitis (JE) in Osaka Prefecture. 4. Relations of summer meteorological conditions to the number of human JE cases and to the size of vector populations, especially with regard to recent low epidemics.] Med. Entomol. Zool. 50: 223-231.

Nakao, M., K. Miyamoto and M. Fukunaga. 1994. Lyme disease spirochetes in Japan: enzootic transmission in birds, rodents, and *Ixodes persulcatus* ticks. J. Infect. Dis. 170: 878-882.

Nelson, B.S. and B. Heischober. 1999. Betel nut: a common drug used by naturalized citizens from India, Far East Asia, and the South Pacific Islands. Ann. Emerg. Med. 34: 238-243.

Nicholls, D.S.H., T.I. Christmas and D.E. Greig. 1990. Oedemerid blister beetle dermatosis: a review. J. Amer. Acad. Dermatol. 22: 815-819.

Niijima, K. and K. Shinohara. 1988. [Outbreaks of the *Parafontaria laminata* group (Diplopoda: Xystodesmidae).] Japan. J. Ecol. 28: 257-268.

Noda, S., S. Yamamoto and K. Uchikawa. 1996. Seasonal occurrence of larval trombiculid mites and distribution of *Leptotrombidium scutellare* in residential area and farmland in Kagoshima Prefecture. Med. Entomol. Zool. 47: 339-346.

Nuttall, P.A. and M. Labuda. 1994. Tick-borne Encephalitis Subgroup. pp. 356-391. *In*: Ecological Dynamics of Tick-Borne Zoonoses, D.A. Sonenshine and T. N. Mather (eds). Oxford University Press.

Ohara, Y., T. Sato and M. Homma. 1998. Arthropod-borne tularemia in Japan: clinical analysis of 1,374 cases observed between 1924 and 1996. J. Med. Entomol. 35: 47–473.

Ohkido, M. 1992. Prophylaxis and therapy for dermatitis caused by harmful insects. Asian Med. J. 35: 471-478.

Ohtaki, N. 1998. [Recent epidemic of scabies in Japan.] Med. Entomol. Zool. 49: 15-26.

Ori, M., E. Shinkai and H. Ikeda. 1996. [Introduction of widow spiders into Japan.] Med. Entomol. Zool. 47: 111-119.

Ou, Z.Y., J.M. Luo and X.C. Luo. 1991. The filariasis situation in Guangdong Province, China. Southeast Asian J. Trop. Med. Public Health 22: 477-488.

Paik, Y.H., Y. Cho and D.S. Koo. 1988. Studies on the current epidemiological situation of Brugian filariasis in endemic areas of Korea. Korean J. Parasitol. 26: 255-262.

Paik, Y.H., H.I. Ree and J.C. Shim. 1988. Malaria in Korea. Japan J. Exp. Med. 58: 55-66.

Pan, Z.A. and Q.Y. He. 1995. [The sero-epidemiological investigation of leptospirosis in Hainan Province.] Chung Hua Liu Hsing Ping Hsueh Tsa Chih 16: 369-371.

Pon, E., K.T. McKee Jr, B.M. Diniega, B. Merrell, A. Corwin and T.G. Ksiazek. 1990. Outbreak of hemorrhagic fever with renal syndrome among US Marines in Korea. Am. J. Trop. Med. Hyg. 42: 612-619.

Qiu, F.X., Q.Q. Chen, Q.Y. Ho, W.Z. Chen, Z.G. Zhao and B.W. Zhao. 1991. The first epidemic of dengue hemorrhagic fever in the People's Republic of China. Am. J. Trop. Med. Hyg. 44: 364-370.

Qiu, F.X., D.J. Gubler, J.C. Liu and Q.Q. Chen. 1993. Dengue in China: a clinical review. Bull. WHO 71: 349-359.

Raoult, D. and V. Roux. 1999. The body louse as a vector of reemerging human diseases. Clin. Infect. Dis. 29: 888-911.

Ree, H.I. 1990. A historical review and prospects of medical entomology research in Korea. Korean J. Parasitol. 28: 145-156.

Ree, H.I. 2000. Unstable vivax malaria in Korea. Korean J. Parasitol. 3: 119-138.

Ree, H.I., W.H. Chang, S.H. Kee, I.Y. Lee and S.H. Jeon. 1997. Detection of *Orientia tsutsugamushi* DNA in individual trombiculids using polymerase chain reaction in Korea. Med. Entomol. Zool. 48: 197-209.

Ree, H.I., M.K. Cho, I.Y. Lee and S.H. Jeon. 1995. Comparative epidemiological studies on vector/reservoir animals of tsutsugamushi disease between high and low endemic areas in Korea. Korean J. Parasitol. 33: 27-36.

Ree, H.I., I.Y. Lee and M.K. Cho. 1991. Determination of the vector species of tsutsugamushi disease in Korea. Korean J. Parasitol. 29: 87-92.

Ree, H.I., I.Y. Lee and M.K. Cho. 1992. Study on vector mites of tsutsugamushi disease in Cheju Island, Korea. Kisaengchunghak Chapchi 30: 341-348.

Ree, H.I., I.Y. Lee, S.H. Jeon and Y. Yoshida. 1997. Geographical distribution of vectors and serostrains of tsutsugamushi disease at mid-south inland of Korea. Korean J. Parasitol. 35: 171-179.

Ree, H.I., H.S. Lee and I.Y. Lee. 1991. Epidemiological studies on host animals of tsutsugamushi disease in Korea. Korean J. Parasitol. 29: 181-188.

Roberts, D.R. and R.G. Andre. 1994. Insecticide resistance issues in vector-borne disease control. Am. J. Trop. Med. Hyg. 50: S21-S34.

Rose, S.T. 2000. International travel health guide, 10th ed. Travel Medicine, Inc., Northampton, MA.

Salafsky, B., K. Ramaswamy, Y.X. He, J. Li and T. Shibuya. 1999. Development and evaluation of LIPODEET, a new long-acting formulation of N, N diethyl-m-toluamide (DEET) for the prevention of schistosomiasis. Am. J. Trop. Med. Hyg. 61: 743-750.

Santana, F.J., J.C. Lien, R. See and P.F.D. Van Peenen. 1979. Annotated bibliography of scrub typhus in Taiwan and the Pescadores Islands (1911-1975). U.S. Navy Med. Res. Unit No. 2, Taipei Spec. Publ. 45pp.

Schmaljohn, C. and B. Hjelle. 1997. Hantaviruses: a global disease problem. Emerg. Infect. Dis. 3: 95-104.

Service, M.W. 1995. Mosquito Ecology: Field Sampling Methods, 2nd ed. Chapman and Hall, London.

Sexton, D.P. and H.P. Willett. 1992. Rickettsiae. pp. 700-718. *In*: Zinsser Microbiology, W.K. Joklik, H.P. Willett, D.B. Amos and C.M. Wilfert (eds.), 20th ed. Appleton and Lange, Norwalk, CT.

Sharma, V.P. 1996. Ecological changes and vector-borne diseases. Trop. Ecol. 37: 57-65.

Shi, M.H., Y.R. Tu and Q.J. Li. 1995. [Study on geographical distribution of leptospirosis in China.] Chung Hua Liu Hsing Ping Hsueh Tsa Chih 16: 259-262.

Shi, Z.J. and D.J. Sun. 1991. Major achievements and experience in filariasis control in the People's Republic of China. Chin. Med. J. 104: 446-453.

Shibata, S., M. Kawahara, Y. Rikihisa, H. Fujita, Y. Watanabe, C. Suto and T. Ito. 2000. New *Ehrlichia* species closely related to *Ehrlichia chaffeensis* isolated from *Ixodes ovatus* ticks in Japan. Am. J. Clin. Microbiol. 38: 1331-1338.

Shih, C.M. and L.L. Chao. 1998. Lyme disease in Taiwan: primary isolation of *Borrelia burgdorferi*-like spirochetes from rodents in the Taiwan area. Am. J. Trop. Med. Hyg. 59: 687-692.

Shim, J.C., C.L. Kim, W.J. Lee and E.H. Shin. 1990. Population densities of *Culex tritaeniorhynchus* for surveillance of Japanese encephalitis in Korea. Korean J. Entomol. 20: 213-222.

Shortridge, K.F., H.W. Lee, J.W. LeDuc, T.W. Wong, G.W. Chau and L. Rosen. 1987. Serological evidence of Hantaan-related viruses in Hong Kong. Trans. R. Soc. Trop. Med. Hyg. 81: 400-402.

Sleigh, A., X. Li, S. Jackson and K. Huang. 1998. Eradication of schistosomiasis in Guangxi, China. Part 1: settings, strategies, operations, and outcomes, 1953-92. Bull. WHO 76: 261-372.

Sleigh, A., X. Li, S. Jackson and K. Huang. 1998. Eradication of schistosomiasis in Guangxi, China. Part 2: political economy, management strategy and costs, 1953-92. Bull. WHO 76: 497-508.

Sleigh, A., X. Li, S. Jackson and K. Huang. 1998. Eradication of schistosomiasis in Guangxi, China. Part 3: community diagnosis of the worst-affected areas and maintenance strategies for the future. Bull. WHO 76: 581-590.

Sleigh, A.C., X.L. Liu, S. Jackson, P. Li and L.Y. Shang. 1998. Resurgence of vivax malaria in Henan Province, China. Bull. WHO 76: 265-270.

Sohn, Y.M. 2000. Japanese encephalitis immunization in South Korea: past, present, and future. Emerg. Infect. Dis. 6: 17-24.

Strickman, D., M.E. Miller, L.L. Kelsey, W.J. Lee, H.W. Lee, K.W. Lee, H.C. Kim and B.H. Feighner. 1999. Evaluation of the malaria threat at the multipurpose range complex, Yongp'yong, Republic of Korea. Mil. Med. 164: 626-629.

Strickman, D., M.E. Miller, H.C. Kim and K.W. Lee. 2000. Mosquito surveillance in the Demilitarized Zone, Republic of Korea, during an outbreak of *Plasmodium vivax* malaria in 1996 and 1997. J. Am. Mosq. Control Assoc. 16: 100-113.

Sucharit, S., K. Surathin and S.R. Shrestha. 1989. Vectors of Japanese encephalitis virus (JEV): species complexes of the vectors. Southeast Asian J. Trop. Med. Public Health 20: 611-621.

Sugiyama, K., K. Minaba, C. Morita, H. Kitamura, T. Yamada, K. Ogura, R. Tanaka, T. Tanikawa, S. Shiga and T. Komatsu. 1993. Epizootiological study of hantavirus infection among *Rattus norvegicus* in Tokyo Bay area, Japan. Jpn. J. Med. Sci. Biol. 46: 75-86.

Sun, D.J. and P.L. Chen. 1992. Filariasis surveillance at the post-control stage in China. Southeast Asian J. Trop. Med. Public Health 23: 369-376.

Takada, N. 1995. Recent findings on vector acari for rickettsia and spirochetes in Japan. Jap. J. Sanit. Zool. 46: 91-108.

Takada, N., H. Fujita, Y. Yano, W.H. Huang and C. Khamboonruang. 1993. Serosurveys of spotted fever and murine typhus in local residents of Taiwan and Thailand compared with Japan. Southeast Asian J. Trop. Med. Public Health 24: 354-356.

Takada, N., F. Ishiguro, H. Fujita, H.P. Wang, J.C. Wang and T. Masuzawa. 1998. Lyme disease spirochetes in ticks from northeastern China. J. Parasitol. 84: 499-504.

Takada, N., F. Ishiguro, H. Iida, Y. Yano and H. Fujita. 1994. Prevalence of Lyme borrelia in ticks, especially *Ixodes persulcatus* (Acari: Ixodidae), in central and western Japan. J. Med. Entomol. 31: 474-478.

Takagi, M., Y. Tsuda, Y. Wada and A. Takafuji. 1995. Decrease of vector mosquitoes of Bancroftian filariasis in a village on Fukue Island, Nagasaki, southwestern Japan. Trop. Med. 37: 159-163.

Takahashi, H. 1984. The number and distribution of sea snakes observed in the Ryukyu Islands, southern Japan. Snake 16: 71-74.

Takashima, I. 1998. Epidemiology of tick-borne encephalitis in Japan. Comp. Immunol. Microbiol. Infect. Dis. 21: 81-90.

Takeda, T., T. Ito, M. Osada, K. Takahashi and I. Takashima. 1999. Isolation of tick-borne encephalitis virus from wild rodents and a seroepizootiological survey in Hokkaido, Japan. Am. J. Trop. Med. Hyg. 60: 287-291.

Tanaka, H. and M. Tsuji. 1997. From discovery to eradication of schistosomiasis in Japan: 1847-1996. Int. J. Parasitol. 27: 1465-1480.

Tang, L.H. 2000. Progress in malaria control in China. Chinese Med. J. 113: 89-92.

Ten, Y.F., H.Y. Zhang and X.C. Xie. 1994. [The natural foci of plague in Xinjiang, China.] Endem. Dis. Bull. 9: 35-41.

Teng, H.J., C.L. Chung, S.T. Wang and T.J. Ho. 1996. [The distribution of dengue vectors and its possible explanation in the coastal area of Chaiyai County.] Chin. J. Epidemiol. 16: 155-165.

Teng, H.J., Y.L. Wu and T.H. Lin. 1999. Mosquito fauna in water-holding containers with emphasis on dengue vectors (Diptera: Culicidae) in Chungho, Taipei County, Taiwan. J. Med. Entomol. 36: 468-472.

Traub, R. and C.L. Wisseman Jr. 1974. The ecology of chigger-borne rickettsiosis (scrub typhus). J. Med. Entomol. 11: 237-303.

Wada, Y., O. Suenaga and I. Miyagi. 1975. Dispersal experiment of *Aedes togoi*. Trop. Med. 16: 137-146.

Walker, D.H. and J.S. Dumbler. 1996. Emergence of the ehrlichioses as human health problems. Emerg. Infect. Dis. 2: 18-29.

Wan, K., Z. Zhang and G. Dou. 1998. [Investigation on primary vectors of *Borrelia burgdorferi* in China.] Chung Hua Liu Ping Hsueh Tsa Chih 19: 263-266.

Wang, C.H., N.T. Chang, H.H. Wu and C.M. Ho. 2000. Integrated control of the dengue vector *Aedes aegypti* in Liu-Chiu village, Ping-Tung County, Taiwan. J. Am. Mosq. Control Assoc. 16: 93-99.

Wang, C.H. and G.D. Roam. 1994. Dengue control in the urban environment of Taiwan. Kao Hsiung I Hsueh Ko Hsueh Tsa Chih 10 Suppl: 28-32.

Wang, L., L.X. Jin and Z.Z. Qi. 1996. [The checklist of arthropods naturally infected with *Yersinia pestis* in each natural focus of plague in China.] Endem. Dis. Bull. 11: 50-53.

Wang, S.B. and Y.Z. Sun. 1999. [The geographic distribution and main ecological characteristics of plague foci in Middle Asia, Russian Siberia and Mongolia.] Endem. Dis. Bull. 14: 83-88.

Wang, Z.F. and W.H. Wang. 1995. [Epidemiological analysis of human plague caused by infected Tibetan sheep in Qinghai during 1975-1994.] Endem. Dis. Bull. 10: 35-37.

Weng, M.H., J.C. Lien, T.G. Ksiazek, C.J. Peters and M.W. Velleca. 1995. Susceptibility of three laboratory strains of *Aedes albopictus* (Diptera: Culicidae) to Japanese encephalitis virus from Taiwan. J. Med. Entomol. 34: 745-747.

Woodruff, D.S., M. Mulvey and M.W. Yipp. 1985. Population genetics of *Biomphalaria stramínea* in Hong Kong. A neotropical schistosome-transmitting snail recently introduced into China. J. Hered. 76: 355-360.

World Health Organization. 1989. Geographical distribution of arthropod-borne diseases and their principal vectors. WHO/VBC/89.967.

World Health Organizaton. 1996. Operational manual on the application of insecticides for the control of mosquito vectors of malaria and other diseases. WHO/CTD/VBC/96.1000.

Wu, Y.C., Y.S. Huang, L.J. Chien, T.L. Lin, Y.Y. Yueh, W.L. Tseng, K.J. Chang and G.R. Wang. 1999. The epidemiology of Japanese encephalitis on Taiwan during 1996-1997. Am. J. Trop. Med. Hyg. 61: 78-84.

Wu, Y.H., H.Y. Su and Y.J. Hsieh. 2000. Survey of infectious skin diseases and skin infestations among primary school students of Taitung County, eastern Taiwan. J. Formos. Med. Assoc. 99: 128-134.

Xirao, R.D. and D.Z. Ciren. 1995. [Study on the epidemiological characteristics of plague in Tibet and its control strategy.] Endem. Dis. Bull. 10: 20-26.

Xu, B., Z. Cui, Y. Zhang, J. Chang, Q. Zha and Q. Huang. 1997. Studies on the transmission potential of surviving microfilaremias after basic control of filariasis. Southeast Asia J. Trop. Med. Public Health 28: 308-313.

Xu, F.L., Z.P. Yang, L. Li, C.Q. Liu and F. Zhao. 1997. [An analysis of plasmid profiles of *Yersinia pestis* isolated from natural plague foci in Xinjiang, China.] Endem. Dis. Bull. 12: 12-15.

Xu, J. and H. Liu. 1997. Border malaria in Yunnan, China. Southeast Asian J. Trop. Med. Public Health 28: 456-459.

Xu, X.J., F.H. Wei, X.X. Yang, Y.H. Dai, G.Y. Yu, L.Y. Chen and Z.M. Su. 2000. Possible effects of the Three Gorges dam on the transmission of *Schistosoma japonicum* on the Jiang Han plain, China. Ann. Trop. Med. Parasitol. 94: 333-341.

Xu, X.J., X.X. Yang, Y.H. Dai, G.Y. Chen and Z.M. Su. 1999. Impact of environmental change and schistosomiasis transmission in the middle reaches of the Yangtze River following the Three Gorges construction project. Southeast Asian J. Trop. Med. Public Health 30: 549-555.

Yabe, T. and H. Hayashi. 1993. [Expansion of scrub terrain and recent epidemic of scrub typhus in western area of Kanagawa Prefecture.] Jap. J. Sanit. Zool. 44: 179-184.

Yang, H.L., D.Q. Liu, Y.M. Yang, K.G. Huang, Y. Dong, P.F. Yang, M.Z. Liao and C.Y. Zhang. 1997. In vitro sensitivity of *Plasmodium falciparum* to eight antimalarials in China-Myanmar and China-Lao PDR border areas. Southeast Asian J. Trop. Med. Public Health. 28: 460-464.

Yang, W., J. Pang and C. Li. 1994. [An investigation of *Leptospira interrogans* in water and soil in southwest of Yunnan Province.] Chung Hua Liu Hsing Ping Hsueh Tsa Chih 15: 289-291.

Yip, K. 1998. Antimalarial work in China: a historical perspective. Parassitologia 40: 29-38.

Yu, S.H. 1996. Control of parasitic diseases in China: current status and prospects. Chin. Med. J. 109: 259-265.

Yu, X. 1993. [Geographical distribution and medical importance of *Ixodes persulcatus* in Xinjiang.] Endem. Dis. Bull. 8: 105-108.

Zhang, H.L., Y.Z. Zhang and Z.Q. Mi. 1993. [Transovarial transmission of chikungunya virus in *Aedes albopictus* and *Aedes aegypti* mosquitoes.] Chin. J. Virol. 9: 222-227.

Zhang, L.M. and Y.J. Leng. 1997. Eighty-year search of phlebotomine sandflies (Diptera: Psychodidae) in China (1915-1995). II. Phlebotomine vectors of leishmaniasis in China. Parasite 4: 299-306.

Zhang, R.G. 1994. [A study on the epidemiological characters and control of human plague in Gansu Province.] Endem. Dis. Bull. 9: 22-26.

Zhang, Z.F., K.L. Wan and J.S. Zhang. 1997. [Studies on epidemiology and etiology of Lyme disease in China.] Chung Hua Liu Hsing Ping Hsueh Tsa Chih 18: 8-11.

Zhao, M. 1991. [The serogroup and serotype distribution of *Leptospira* in Sichuan Province from 1958 to 1987.] Chung Hua Liu Hsing Ping Hsueh Tsa Chih 12: 226-230.

Zhong, H.L., L.Y. Le and W.J. Cao. 1981. Present situation of filariasis in China. Chin. Med. J. 94: 567-584.

Zhu, J.Q., W.L. Wu, Y.Z. Li, G. Liu and C.M. Wang. 1993. [A study on the epidemic patterns and control measures of human plague in Qinghai Province.] Endem. Dis. Bull. 8: 1-8.

Zizhao, L., S. Luoyuan, Z. Lian, L. Dongfang and S. Yunpu. 1999. Control strategies of malaria in Henan Province, China. Southeast Asian J. Trop. Med. Public Health 30: 240-242.

Appendix B
Pesticide Resistance in East Asia

Vector-borne diseases are an increasing cause of death and suffering in many areas of the world. Efforts to control these diseases have been founded on the use of chemical pesticides. However, the spread of resistance among arthropods has rendered many pesticides ineffective, while few substitute pesticides are being developed. Resistance has been reported to every class of insecticides, including microbial agents and insect growth regulators.

Resistance is formally defined by the World Health Organization as "the development of an ability in a strain of some organism to tolerate doses of a toxicant that would prove fatal to a majority of individuals in a normal population of the same species." Resistance has a genetic basis and is the result of a change in the genetic composition of a population as a direct result of the selection effects of the pesticide.

Early detection and monitoring are vital to resistance management. Historically, standardized methods, test kits and insecticides were provided by WHO. The simplest method of detecting resistance is the diagnostic dose test. The diagnostic dose is a predetermined insecticide dose known to be lethal to a high proportion of susceptible individuals, but that a high proportion of resistant individuals can tolerate. A list of recommended diagnostic doses of many insecticides for a number of arthropod vectors is available from WHO. For terrestrial and/or adult stages, the insecticide is either applied topically or insects are exposed to a surface treated with insecticide. For aquatic stages, insecticide is added to water at given concentrations.

New approaches use rapid biochemical tests to detect resistance and determine resistance mechanisms. These methods permit rapid multiple assays of a single specimen. Worldwide application of biochemical assays will require production of standardized kits similar to the insecticide bioassay kits supplied by WHO. The choice of method to test for resistance is of great importance in order to determine resistance mechanisms. Consult TG 189, Procedures for the Diagnostic Dose Resistance Test Kits for Mosquitoes, Body Lice, and Beetle Pests of Stored Products. To obtain test kits and additional recommendations for resistance testing contact:

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Pesticide resistance can be classified into 2 broad categories: physiological and behavioral. There are many mechanisms of physiological resistance, including reduced penetration of insecticides through the cuticle, presence of enzymes that detoxify the insecticide, and reduced sensitivity of the target site of the insecticide. Physiological resistance can confer cross-resistance to structurally related insecticides of the same chemical class or related classes. Some vector populations have acquired several resistance mechanisms providing multiple resistance to a variety of insecticide classes. Many vector control programs have reached a stage where resistance is so great that few chemical alternatives are available.

In recent years, synthetic pyrethroids have replaced widely used classes of insecticides such as organophosphates, carbamates, and chlorinated hydrocarbons. These pyrethroids have shown great promise for vector control due to their low mammalian toxicity and ability to quickly immobilize and kill arthropods at low dosages. Unfortunately, resistance has been detected in several medically important arthropods. An issue of concern in vector control is whether DDT resistance confers cross-resistance to pyrethroids as a result of similar resistance mechanisms. Increasing pyrethroid resistance is of particular concern to the U.S. military because of the widespread use of permethrin and other pyrethroids in BDUs, bednets, and vector control programs. Studies indicate that resistance appears rapidly in areas where treated bednets are used to control mosquitoes.

Changes in behavior that result in reduced contact with an insecticide include a reduced tendency to enter treated areas or an increased tendency to move away from a surface treated with insecticide once contact is made. These are population-based changes in a species' genetics resulting from the selection pressure of insecticide use. Avoidance behavior is widespread but poorly understood. Some form of behavioral avoidance has been documented for virtually every major vector species. Methods to detect and determine behavioral resistance have not been standardized and are difficult to interpret.

Pesticide resistance will be an increasing problem for vector control personnel. More than 90% of all pesticides are used for agricultural purposes. Insecticide resistance in at least 17 species of mosquitoes in various countries has occurred because of indirect selection pressure by agricultural pesticides. The agricultural use of insecticides in rice paddies has greatly contributed to the development of resistance in several species of *Anopheles* and *Culex* in many areas of East Asia.

Innumerable genetic, biologic and operational factors influence the development of insecticide resistance. A pesticide use strategy that will prevent the evolution of resistance has not been developed. Tactics to manage or delay the development of resistance include: 1) using nonchemical methods of control as much as possible, 2) varying the dose or frequency of pesticide application, 3) using local rather than area-wide application, 4) applying treatments locally only during outbreaks of vector-borne diseases, 5) using less persistent pesticides, 6)

treating only certain life stages of the vector, 7) using mixtures of pesticides with different modes of action, 8) using improved pesticide formulations, 9) rotating pesticides having different modes of action, and 10) using synergists.

Reports of resistance must be interpreted carefully. Many reports of resistance for a vector species are based on single data sets from a single point within a country and may be years if not decades old. Resistant populations tend to revert to susceptible status once insecticide selection pressure has been removed. Isolated reports of resistance, although recent, may indicate local resistance that has not become widespread. Vector control personnel frequently assume that resistance in a particular species occurs throughout their control area, but in reality, insecticide resistance is focal. The length of time an insecticide has been used at a location may not be helpful in predicting the presence of resistance. Vectors in some countries have never developed resistance to DDT, despite decades of use in malaria control. Only appropriate resistance monitoring can guide the vector control specialist in the selection of a suitable insecticide.

Published Reports of Insecticide Resistance Testing in East Asia.*

Bang, Y.H. 1985. Implications in the control of malaria vectors with insecticides in tropical countries of South-east Asia region. Part I. Insecticide resistance. J. Commun. Dis. 17: 199-218.

Bang, Y.H. 1985. Implications in the control of malaria vectors with insecticides in tropical countries of South-east Asia region. Part II. Consequences of insecticide use. J. Commun. Dis. 17: 300-310.

Lines, J.D. 1988. Do agricultural insecticides select for insecticide resistance in mosquitoes? A look at the evidence. Parasitol. Today 4: 17-20.

World Health Organization. 1986. Resistance of vectors and reservoirs of disease to pesticides. Tenth report of the WHO expert committee on vector biology and control. WHO Tech. Rep. Ser. 737: 87 pp.

China

Cao,Y.P., Y.D. Dong and L.H. Zhu. 1997. [Cross-resistance study of *Culex pipiens pallens* of a permethrin-resistant strain with deltamethrin and alpha-cypermethrin.] Chinese J. Vector Biol. Control 8: 167-168.

Chao, L.C., S.C. Liao and W.C.J. Maa. 1993. [Resistance of housefly, *Musca domestica* L., to dichlorvos, malathion, pirimiphos-methyl and propoxur in Lo-tung area.] Chinese J. Entomol. 13: 17-25.

Cheng, J.X., T.Y. Zhao, L.H. Zhu, B.L. Lu and Y.D. Dong. 1998. [Selection of resistant strain of *Culex pipiens pallens* to lambda-cyhalothrin and its cross-resistance to other insecticides.] Acta Parasitol. Med. Entomol. Sin. 5: 106-111.

Cheng, J.X. L.H. Zhu and T.Y. Zhao. 1998. [A study on a strain of *Culex pipiens pallens* selected for resistance to tetramethrin.] Chinese J. Vector Biol. Control 9: 89-91.

Cheng, J.X., L.H. Zhu and T.Y. Zhao. 1998. [Selection of the resistant strains of *Culex pipiens* to deltamethrin.] Chinese J. Vector Biol. Control 9: 180-182.

Cheng, J.X., L.H. Zhu, T.Y. Zhao, Y.D. Dong and H. Yu. 1998. [Esterase of houseflies of permethrin resistance.] Acta Parasitol. Med. Entomol. Sin. 5: 45-48.

Dong, Y.D., L.H. Zhu, L.H. Zhao, H. Yu and B.L. Lu. 2000. [Studies on the differentiation of permethrin-resistant strain of *Musca domestica*.] Acta Parasitol. Med. Entomol. Sin. 7: 40-45.

Feng, G.L., Y. Zhao and F.Q. He. 1993. [Study on pyrethroid resistance of houseflies.] Chinese J. Public Health 12: 30-31, 44.

Feng, N.G., Y. Ou, H.B. Ou, Q.Q. Cen and S.H. Liu. 1999. [Survey of resistance to blood coagulating compounds in the brown house mouse in Shenzhen.] Chinese J. Vector Biol. Control 10: 467-468.

Geng,W.K., X.Y. Feng and L.H. Huang. 2000. [Study on abiding efficacy of cypermethrin and *Bacillus thuringiensis* mixture to *Culex pipiens quinquefasciatus* in the laboratory.] Chinese J. Vector Biol. Control 11: 112-114.

Gu, J., S.Y. Chen and R. Sun. 2000. [Resistance of house fly to seven kinds of insecticides and its control strategies in Nantong city.] Chinese J. Vector Biol. Control 11: 123-125.

He, F.Q., M. Li, G.L. Feng and K.Y. Gong. 1993. [Synergism of several compounds to pyrethroids for the housefly.] Chinese J. Public Health 12: 349-351.

Huang, G., J.M. Liu and W.Y. Liu. 1999. [Resistance to five pesticides of *B. germanica* from cities of Hebei Province.] Chinese J. Vector Biol. Control 10: 285-287.

Huang, T.Y., X.L. Wang, D.X. Xiao, S.X. He, T.X. Li, Y.H. Zhou, Z.Z. Song, J.Y. Yang and P.C. Yang. 1987. [Effectiveness of "hunmiewei" and deltamethrin residual spraying in controlling *Anopheles sinensis*.] Chinese J. Parasitol. Parasit. Dis. 5: 184-187.

Huo, X.B., X.J. Wang and X.L. Wu. 1997. [Analyses of current insecticide resistance to house flies in Shandong Province.] Chinese J. Vector Biol. Control 8: 273-274.

Jiang, J.L., J.H. Shen and W.D. Liu. 1985. [Mechanism of pyrethroid-resistance in mosquito larvae *Culex pipiens pallens* Coq. and its control.] Contrib. Shanghai Inst. Entomol. 5: 105-111.

Jiang, J.L., Z.Y. Zhang and W.D. Liu. 1986. [Studies on the cross-resistance to DDT, organophosphate and permethrin in the resmethrin-selected mosquito, *Culex pipiens pallens* Coq.] Contrib. Shanghai Inst. Entomol. 4: 113-119.

Jiang, S., X.L. Han, W.J. Zhang, N.C. Chen and J.T. Luo. 1993. [The synergistic mechanism of phoxim and fenvalerate in pyrethroid resistant house flies.] Acta Phytophylacica Sin. 20: 357-362.

Jinfu, W. 1999. Resistance to deltamethrin in *Anopheles sinensis* from Zhejiang, China. J. Am. Mosq. Control Assoc. 15: 308-311.

Kang, W., B. Gao, H. Jiang, H. Wang, T. Yu, P. Yu, B. Xu and C.F. Curtis. 1995. Tests for possible effects of selection by domestic pyrethroids for resistance in culicine and anopheline mosquitoes in Sichuan and Hubei, China. Ann. Trop. Med. Parasitol. 89: 677-684.

Li, A., F. Xu and M.F. Ouyang. 1999. [Analyses of present situation of resistance for *Culex fatigans* in Jiangxi Province.] Chinese J. Vector Biol. Control 10: 108-110.

Li, Y.L., C.L. Zhu and C.L. Xu. 1999. [Susceptibility to 15 insecticides of deltamethrin-resistant *Culex pipiens pallens*.] Chinese J. Vector Biol. Control 10: 16-17.

Lin, L.F., W.C. Lu and S.W. Cai. 2000. [Monitoring for insecticide resistance in field-collected strains of the German cockroach in Guangdong.] Chinese J. Vector Biol. Control 11: 32-34.

Lin, L.F., Z.H. Zhang and L.P. Liu. 1999. [Resistance of *Musca domestica* and its management strategies.] Chinese J. Vector Biol. Control 10: 21-23.

Lin, L.F., Z.H. Zhang and L.P. Liu. 1999. [Study on a polymerase chain reaction (PCR) analysing the insecticide resistance in the housefly, *Musca domestica*.] Chinese J. Vector Biol. Control 10: 117-120.

Lin, L.H. 1993. [Susceptibility of *Musca domestica vacina* to five insecticides in Guangzhou.] Ann. Bull. Soc. Parasitol. 12: 14-15.

Liu, C.S., W.N. Wu and J.L. Zhang. 1997. [Analysis on the effects of anticoagulant rodenticides for ten year use in the residential quarters in Changsha Islet, Zongyang County, Anhui Province.] Chinese J. Vector Biol. Control 8: 244-248.

Liu, F.M., T.M. Zhen and Y.Q. Zhao. 2000. [Insecticidal resistance of *Culex pipiens pallens* in Jining City in 1991-1997.] Chinese J. Vector Biol. Control 11: 30-31.

Liu, J.E., C.L. Qiao, L.P. Chen and Z.Q. Sun. 2000. Amplified esterases B1 and A2-B2 in field populations of *Culex pipiens* from China. J. Am. Mosq. Control Assoc. 16: 143-147.

Liu, J.E., C.L. Qiao and Z.Q. Sun. 1999. New esterase enzymes involved in organophosphate resistance in *Culex pipiens* (Diptera: Culicidae) from Guang Zhou, China. J. Med. Entomol. 36: 666-670.

Liu, L.P., L.F. Lin and Z.H. Zhang. 1999. [Study on intigrate degree of esterase activity in organophosphate-resistant *Culex quinquefasciatus* (Diptera: Culicidae) of Guangdong Province.] Chinese J. Vector Biol. Control 10: 270-273.

Liu, L.P., L.F. Lin and Z.H. Zhang. 1999. [Survey on the resistance of *Culex quinquefasciatus* to several common insecticides in cities of Guangdong Province.] Chinese J. Vector Biol. Control 10: 410-414.

Liu, W.D. and W.M. Chen. 1984. [The potency of insecticide resistance of *Anopheles sinensis* Wied. in China.] Contrib. Shanghai Inst. Entomol. 4: 313-319.

Neng, W., X. Yan, H. Fuming and C. Dazong. 1992. Susceptibility of *Aedes albopictus* from China to insecticides, and mechanism of DDT resistance. J. Am. Mosq. Control Assoc. 8: 394-397.

Pan, K.Y., Z.L. Chen and Z.H. Ma. 1997. [Present situation and developing trends of resistance for house fly to pesticides in Suzhou City.] Chinese J. Vector Biol. Control 8: 270-272.

Pan, K.Y., Z.L. Chen, S.R. Xu, Y.D. Huang and Z.H. Ma. 1997. [Studies on resistance of housefly to insecticide and the countermeasures taken in Suzhou.] Chinese J. Parasitol. Parasit. Dis. 15: 305-307.

Qian, W.P. 1998. [Studies of resistance of *Culex quinquefasciatus* larva in Chengdu area to several insecticides.] Chinese J. Vector Biol. Control 9: 427-428.

Qiao, C.L., M. Marquine, N. Pasteur and M. Raymond. 1998. A new esterase gene amplification involved in OP resistance in *Culex pipiens* mosquitoes from China. Biochem. Genetics 36: 417-426.

Qin, D., J.M. Lou and W.J. Dong. 1998. [First determination of insecticide resistance of housefly in three cities of southern Xinjiang.] Chinese J. Vector Biol. Control 9: 436-438.

Qiu, L.H., X.F. Li, C.J. Wang and W.J. Zhang. 1999. [Changes in susceptibility of resistant housefly to pesticides and its mechanisms under different insecticide applications.] Acta Entomol. Sin. 42: 248-256.

Qiu, L.H. and W.J. Zhang. 1999. [Studies on the cross-resistance to organophosphorus and pyrethroids in housefly strains possessing different level resistance to phoxim and deltamethrin.] J. China Agricult. Univ. 4: 86-92.

Sun,Y.Q., J.G. Yuan, J. Li, F.Q. He, B.W. Liu, J. Wang and K.Y. Gong. 1990. [The resistance mechanism of housefly against pyrethroids.] Acta Entomol. Sin. 33: 265-273.

Tang, Z.H. 1986. Studies on malathion resistance and its mechanism in *Culex pipiens pallens*. Contrib. Shanghai Inst. Entomol. 6: 115-122.

Tang, Z.H. and Y.G. Li. 1985. [Studies on the rotational and mixed use of malathion and Dipterex in *Culex pipiens pallens*: esterase isozymes in relation to resistance.] Acta Entomol. Sin. 28: 135-141.

Tang, Z.H., Q.F. Han and P.J. Zhuang. 1991. [Carboxylesterase and acid phosphatase profile during the life span of the OP-resistant and susceptible *Culex pipiens pallens*.] Acta Entomol. Sin. 34: 13-19.

Their, S.P. 1997. Pesticides in China: policy and practice. Pestic. Outlook 8: 6-10.

Wang, J.F. 1999. Resistance to deltamethrin in *Culex pipiens pallens* (Diptera: Culicidae) from Zhejiang, China. J. Med. Entomol. 36: 389-393.

Wang, J.F. 1999. Resistance to two pyrethroids in *Anopheles sinensis* from Zhejiang, China. J. Am. Mosq. Control Assoc. 15: 308-311.

Wang, J.F. 1999. Stability of organophosphate resistance in *Culex pipiens pallens* Coquillett under relaxation of insecticide selection. Entomol. Sin. 6: 271-276.

Wang, J.F. 2000 Resistance and response to selection to deltamethrin in *Anopheles sinensis* from Zhejiang, China. J. Am. Mosq. Control Assoc. 16: 9-12.

Wang, J.F., R. Chen, S.H. Lu and J.N. Xu. 1999. [PCR identification and probability of amplified esterase genes in *Culex pipiens pallens*.] Acta Entomol. Sin. 42: 257-263.

Wang, J.F. and S.H. Lu. 1999. Esterase activity and organophosphate resistance in *Culex pipiens pallens* (Diptera: Culicidae) populations in Zhejiang. J. Econ. Entomol. 92: 176-179.

Wang, J.F., S.H. Lu, R. Chen and L.L. Wang. 1997. [Analysis on the relative fitness of three organophosphate resistant strains of *Culex pipiens pallens*.] Acta Parasitol. Med. Entomol. Sin. 4: 145-150.

Wang, J.F., S.H. Lu, R. Chen and L.L. Wang. 1998. Relative fitness of three organophosphate-resistant strains of *Culex pipiens pallens* (Diptera: Culicidae). J. Med. Entomol. 35: 716-719.

Wang, J.F., S.H. Lu, C. Rui and L.L. Wang. 1998. Analysis on life table of organophosphate-resistant strains of *Culex pipiens pallens*. Entomol. Sin. 5: 159-165.

Wang, J.F., S.H. Lu, H.Y. Shen and J.X. Chen. 1996. [Analysis of the probability of high esterase activity and the tendency of organophosphate resistance in *Culex pipiens pallens* populations.] Acta Parasitol. Med. Entomol. Sin. 3: 223-230.

Wang, S.C., D.H. Liu and L. Xing. 1998. [Study on resistance of *Culex pipiens pallens* to insecticide in Liaoning Province.] Chinese J. Vector Biol. Control 9: 101-102.

Wang, S.Z., Y.Z. Luo and M.L. Wang. 2000. [Investigation of *Culex pipiens pallens* larva against three usual insecticides in Shanghai area.] Chinese J. Vector Biol. Control 11: 268-270.

Wang, X.G., T.M. Zhen and F.M. Liu. 1999. [Cross-resistance of resistant strain of *Culex pipiens pallens* to chemical insecticides.] Chinese J. Vector Biol. Control 10: 18-20.

Wang, Z.L. 1995. [Present situation of insecticidal resistance of mosquitoes in Shandong province.] Chinese J. Parasitic Dis. Control 8: 225-227.

Wu, N., Y. Xiao and F. Huang. 1992. Susceptibility of *Aedes albopictus* from China to insecticides, and mechanisms of DDT resistance. J. Am. Mosq. Control. Assoc. 8: 394-397.

Xiong, G.H. and C.F. Jin. 1988. Studies on deltamethrin in the control of peri-wild *Phlebotomus chinensis*. Excerpta Med. Int. Congr. Ser., Netherlands 810: 43.

Xiong, M.H., Y.D. Zou and L.N. Xu. 1998. [Comparative study on soluble proteins in *Culex fatigans* larvae and pesticide-resistant larvae in Guizhou.] Chinese J. Vector Biol. Control 9: 14-16.

Xu, F., A. Li and X.L. Duan. 1999. [Studies on insecticide resistance and control strategy of *Culex fatigans* in Nanchang area.] Chinese J. Vector Biol. Control 10: 111-113.

Xu, J.N., F.Y. Qu and W.D. Liu. 1994. [Biochemical mechanisms of organophosphate resistance in *Culex pipiens* complex mosquitoes from China.] Acta Parasitol. Med. Entomol. Sin. 1: 39-44.

Xu, J.W. and H. Liu. 1998. [Development of resistance by *Anopheles sinensis* and *An. minimus* to DDT in Yunnan Province.] Chinese J. Parasitic Dis. Control 11: 358.

Xue, J., J.C. Liu and G.Z. Zhou. 1999. Study on the resistance and the killing of *Rattus norvegicus* to anticoagulant rodenticides in Jinan Military Area. Chinese J. Vector Biol. Control 10: 6-9.

Yang, Z.J., J.H. Sun, G.F. Lin and W.D. Liu. 1988. [Studies on carboxylesterase in organophosphorus resistant and susceptible *Culex tritaeniorhynchus* mosquitoes.] Acta Entomol. Sin. 31 243-248.

Yang, Z.Q., J.F. Liu and W.D. Liu. 1985. [Studies on the insecticide resistance of *Culex tritaeniorhynchus* Giles in China.] Contrib. Shanghai Inst. Entomol. 5: 123-130.

Yu, P.H., Z.F. Fu and H.X. Zhang. 2000. [A survey on the susceptibility of *Anopheles* vectors to DDT in the area of residual spraying implementation for three years.] Chinese J. Parasit. Dis. Contr. 13: 105.

Yu, P.H., H.X. Zhang, G.Z. Ming, J. Shi and B.Z. Xu. 1997. [Field study on insecticide resistance of *Anopheles* in areas where deltamethrin-impregnated mosquito nets have been used to control malaria for 6 years.] Acta Parasitol. Med. Entomol. Sin. 4: 33-38.

Yuan, Z.M., Y.M. Zhang, Q.X. Cai and E.Y. Liu. 2000. High-level field resistance to *Bacillus sphaericus* C3-41 in *Culex quinquefasciatus* from southern China. Biocontrol Sci. Technol. 10: 41-49.

Yue, M.S., L.Y. Zhang and K.L. Liu. 1999. [Analyses of current insecticide resistance of house fly in the flood region of Hubei.] Chinese J. Vector Biol. Control 10: 354-357.

Zeng, X.P., H.P. Ke and J.B. Hu. 1998. [Resistance determination on four kinds of insecticides with field-collected German cockroaches in Beijing.] Chinese J. Vector Biol. Control 9: 344-346.

Zhang, D.Y., J.A. Cheng and Y.H. Lu. 1997. [Studies on insecticide resistance and synergism in *Blattella germanica*. (L.) in urban Hangzhou.] Chinese J. Vector Biol. Control 8: 114-118.

Zhang, D.Y., J.A. Cheng, H.M. Wu and H.J. Mao. 1999. [The insecticides resistance of German cockroach *Blattella germanica* L. and the role of mixed function oxidase in insecticides resistance.] J. Zhejiang Agricult. Univ. 25: 303-306.

Zhang, W.J., X.L. Han, X.F. Li and Z.G. Yuan. 1995. [The effect of mixtures of phoxim and deltamethrin on development of resistance in houseflies.] Acta Entomol. Sin. 38: 25-29.

Zhang, Z.H., L.P. Liu and L.F. Lin. 1999. [Study on filter paper test for rapid detecting and quantifying esterase activity in resistant housefly, *Musca domestica*.] Chinese J. Vector Biol. Control 10: 24-27.

Zhang, Z.X. and C.J. Yang. 1996. Application of deltamethrin-impregnated bednets for mosquito and malaria control in Yunnan, China. Southeast Asian J. Trop. Med. Public Health 27: 367-371.

Zhang, Z.Y. 1986. [Cross-resistance to other pyrethroids of resmetherin-resistant *Culex pipiens pallens*.] Acta Entomol. Sin. 29: 131-138.

Zhang, Z.Y. 1987. [Further investigation of synergist and cross-resistance to non-pyrethroids in resmethrin-selected mosquito, *Culex pipiens pallens* Coq.] Contrib. Shanghai Inst. Entomol. 6: 109-114.

Zhang, Z.Y. and Z.H. Tang. 1990. [Comparative fitness of different genotypes of malathion-resistant *Culex pipiens pallens*.] Contrib. Shanghai Inst. Entomol. 8: 139-146.

Zhao, Y.Q., T.M. Zhen and S.G. Li. 1999. [Microplate test for the determination of acetylcholinesterase in vector mosquitoes.] Chinese J. Vector Biol. Control 10: 99-101.

Zhou, E., C.A. Cheng and S.F. Zhang. 1999. [Resistant investigation against *Rattus norvegicus* for six years in Geijing.] Chinese J. Vector Biol. Control 10: 340-342.

Zhou, G.L., J.L. Huang, Q.F. Yao, X.M. Zan, C.X. Ge and L. Wang. 2000. [Isolation and identification of a fragment of CYP6 gene from deltamethrin-resistant strain genome of *Aedes albopictus*.] Chinese J. Zoonoses 16: 22-25.

Zhou,Y.D. 1998. The control test of esterase of *C. fatigans* and the susceptibility to Dipterex. Chinese J. Vector Biol. Control 9: 183-184.

Zhu, C.L., Y.L. Li, L.X. Sun, X.H. Gao, B.H. Ye and J.M. Li. 1998. [Genetic analysis of deltamethrin resistance in *Culex pipiens pallens*.] Chinese J. Parasitol. Parasit. Dis. 16: 21-24.

Zhu, C.L., H.S. Tian, J.M. Li, X.Z. Yu and B.H. Ye. 1998. [Identification of deltamethrin-resistant mosquito, *Culex pipiens pallens*, with RAPD-PCR.] Chinese J. Parasit. Dis. Control 11: 214-216.

Japan

Amano, K., T. Hasegawa and H. Hayakawa. 1982. Comparison of the susceptibilities of the adults of *Musca hervei* with those of *M. domestica* to several insecticides by settling mist method. Annu. Rep. Plant Prot. North Jap. 33: 133-138.

Fukase, T. and H. Itagaki. 1991. [Insecticidal effect of a synthetic pyrethroid, cyfluthrin on adult house flies, *Musca domestica*.] J. Japan Vet. Med. Assoc. 44: 1-6.

Funaki, E. and N. Motoyama. 1986. Cross resistance to various insecticides of the housefly selected with a pyrethroid. J. Pestic. Sci. 11: 219-222.

Funaki, E., Y. Tabaru and N. Motoyama. 1986. [Current status of pyrethroid resistance in the housefly in Kanto area.] J. Pestic. Sci. 11: 261-266.

Henna, M. and T. Keruma. 1990. [Susceptibility of *Boophilus microplus* collected from Kuro Island to several tickicide drugs.] J. Japan Vet. Assoc. 43: 436-440.

Ikemoto, T. 1996. [Ecological diversities of *Anopheles sundaicus* as a vector mosquito of malaria.] Med. Entomol. Zool. 47: 1-13.

Imai, C. 1984. Development and loss of insecticide resistance in the houseflies, *Musca domestica*, at a waste disposal site in relation to insecticide application. Jap. J. Sanit. Zool. 35: 225-231.

Kamimura, K. and R. Arakawa. 1991. Field evaluation of an insect growth regulator, pyriproxyfen, against *Culex pipiens pallens* and *Culex tritaeniorhynchus*. Jap. J. Sanit. Zool. 42: 249-254.

Kamimura, K. and Y. Maruyama. 1983. [Appearance of highly resistant strain of *Culex tritaeniorhynchus* to organophosphorus insecticides.] Jap. J. Sanit. Zool. 34: 33-37.

Kawada, H., Y. Shono, T. Ito and Y. Abe. 1993. Laboratory evaluation of insect growth regulators against several species of anopheline mosquitoes. Jap. J. Sanit. Zool. 44: 349-353.

Kawakami, Y. 1989. [Insecticide resistance of *Culex pipiens molestus* Forskal collected in Shinjuku-ku, Tokyo.] Jap. J. Sanit. Zool. 40: 217-220.

Kono, Y. and T. Tomita. 1993. A role of highly active carboxylesterase in an organophosphorus insecticide resistant strain of *Culex pipiens molestus*. Jap. J. Sanit. Zool. 44: 15-21.

Kudamatsu, A., A. Hayashi and R. Kano. 1983. Patterns of cross resistance to insecticides in the housefly in Japan. pp. 411-419. *In*: Pest resistance to pesticides. G.P. Georghiou (ed.) Plenum Press, NY.

Mihara, M. and T. Shono. 1991. Effects of allethrin fumigation against pyrethroid resistant *Culex tritaeniorhynchus* adults. Jap. J. Sanit. Zool. 42: 15-19.

Miyagi, I., T. Toma, N. Zayasu and Y. Takashita. 1994. Insecticide susceptibility of *Culex quinquefasciatus* larvae (Diptera: Culicidae) in Okinawa Prefecture, Japan in 1989. Jap. J. Sanit. Zool. 45: 7-11.

Motoyama, N. 1984. Pyrethroid resistance in a Japanese colony of the housefly. J. Pestic. Sci. 9: 523-526.

Takada,Y. 1997. The *in vivo* mechanism of housefly resistance to permethrin. Resistant Pest Mgmt. 9: 16-20.

Takada,Y., T. Hiroyoshi and M. Hirano. 1988. Linkage group analysis of permethrin resistance in the Miyakonojo colony of the housefly, *Musca domestica* L. (Diptera: Muscidae). Appl. Entomol. Zool. 23: 122-126.

Takahashi, M. and K. Yasutomi. 1987. Insecticidal resistance of *Culex tritaeniorhynchus* (Diptera: Culicidae) in Japan: genetics and mechanisms of resistance to organophosphorus insecticides. J. Med. Entomol. 24: 595-603.

Taniguchi, N., T. Kato and Y. Ikeda. 1985. Rodenticidal activity of warfarin against wild Norway rat, *Rattus norvegicus*, collected from some locations in Japan. Jap. J. Sanit. Zool. 36: 107-110.

Tanikawa, T. 1991. [Difference in consumption of warfarin baits and lethal days between resistant and susceptible colonies of the roof rat, *Rattus rattus*, in Japan.] Jap. J. Sanit. Zool. 42: 99-102.

Tanikawa, T. 1992. [Studies on genetic analysis of warfarin resistance in roof rats, *Rattus rattus*, in Japan by crossing resistant and susceptible colonies.] Jap. J. Sanit. Zool. 43: 323-329.

Tanikawa, T., Y. Iwaki, Y. Kawakami, Y. Murata, N. Taniguchi and A. Uchida. 2000. [Warfarin susceptibility of the wild brown rats, *Rattus norvegicus*, captured in 11 localities in Japan.] Med. Entomol. Zool. 51: 95-100.

Tanikawa, T. and T. Suzuki. 1993. [An analysis of the lethal feeding period of warfarin in several populations of roof rats, *Rattus rattus*.] Jap. J. Sanit. Zool. 44: 293-298.

Toma, T., I. Miyagi, T. Kishimoto, Y. Higa, H. Hatazoe and N. Zayasu. 1993. Insecticidal resistance of *Culex tritaeniorhynchus* Giles (Diptera: Culicidae) in Okinawa Prefecture, Japan, in 1970-1972 and 1989. Jap. J. Sanit. Zool. 44: 263-269.

Toma, T., I. Miyagi, W.L.M. Malenganisho and M. Tamashiro. 1998. Insecticide susceptibility of *Anopheles minimus, An. saperoi* and *An. sinensis* larvae (Diptera: Culicidae) in Okinawa Prefecture, Japan, in 1993 and 1994. Med. Entomol. Zool. 49: 227-230.

Toma, T., I. Miyagi and M. Tamashiro. 1994. Insecticidal susceptibility of the larvae of *Aedes albopictus*, *Culex quinquefasciatus* and *Cx. boninensis* (Diptera: Culicidae) collected from Chichijima, Ogasawara Islands, Japan. Jap. J. Sanit. Zool. 45: 75-78.

Umeda, K., T. Shono, M. Hirano and M. Takahashi. 1990. Reduced nerve sensitivity as a resistant mechanism to a pyrethroid in *Culex tritaeniorhynchus* from Okinawa. J. Pestic. Sci. 15: 599-601.

Umeda, K., T. Yano and M. Hirano. 1988. Pyrethroid-resistance mechanism in German cockroach, *Blattella germanica* (Orthoptera: Blattellidae). Applied Entomol. Zool. 23: 373-380.

Watanabe, M., R. Arakawa and K. Kamimura. 1990. [Relationship between yearly change of captured numbers and insecticide resistance of *Culex tritaeniorhynchus* in Toyama Prefecture.] Jap. J. Sanit. Zool. 41: 51-58.

Watanabe, M., S. Takebe and R. Arakawa. 1991. [Susceptibility to nineteen insecticides and esterase activity in *Anopheles omorii*.] Jap. J. Sanit. Zool. 42: 33-42.

Yano, T., Y. Takada, M. Hirano and I. Nakayama. 1994. Changes in population density, habitat preference and susceptibility to insecticides of cockroaches inhabiting in an underground shopping arcade in Osaka. Jap. J. Sanit. Zool. 45: 253-263.

Yasutomi, K., M. Mihara and C. Shudo. 1988. [Succession of insecticide resistance in the houseflies of the third Yumenoshima, a dumping-island of Tokyo, 1978-1986.] Jap. J. Sanit. Zool. 39: 43-47.

Yasutomi, K. and M. Takahashi. 1987. Insecticidal resistance of *Culex tritaeniorhynchus* (Diptera: Culicidae) in Japan: a country-wide survey of resistance to insecticides. J. Med. Entomol. 24: 604-608.

Yasutomi, K. and M. Takahashi. 1989. [Insecticidal resistance of *Culex tritaeniorhynchus* in Chinen, Okinawa Prefecture, with special reference to the mechanism of pyrethroid resistance]. Jap. J. Sanit. Zool. 40: 315-321.

Yasutomi, K., K.I. Urabe and Y. Wada. 1986. [Insecticide-resistance of *Anopheles sinensis* and *Culex tritaeniorhynchus* in Saitama Prefecture, Japan.] Jap. J. Sanit. Zool. 37: 357-362.

Zhang, L., K. Harada and T. Shono. 1997. Genetic analysis of pyriproxyfen resistance in the housefly, *Musca domestica* L. Applied Entomol. Zool. 32: 217-226.

South Korea

Baik, D.H. and C.Y. Joo. 1991. Epidemio-entomological survey of Japanese encephalitis in Korea. Korean J. Parasitol. 29: 67-85.

Baik, D.H., J.B. Kim and C.Y. Joo. 1987. Insecticide resistance of *Anopheles sinensis* and *Culex tritaeniorhychus* in Korea. *In*: Abstracts of the spring meeting of the Korean Society for Parasitology 25: 95-96.

Kim, G.H., Y.H. Choi, J.H. Kim and K.Y. Cho. 1997. [The resistant level of the housefly, *Musca domestica* L. to several insecticides from various localities in Korea.] Korean J. Entomol. 27: 305-312.

Lee, D.K. and J.C. Shim. 1999. Insecticide susceptibility of house fly (*Musca domestica*) adults in Korea. Korean J. Entomol. 29: 177-180.

Lee, D.K., E.H. Shin and J.C. Shim. 1997. Insecticide susceptibility of *Culex pipiens pallens* (Culicidae, Diptera) larvae in Seoul. Korean J. Entomol. 27: 9-13.

Lee, K.W., R.L. Frommer and T.K. Lee. 1984. A study on the resistance of commensal rodents to an anticoagulant bait in Korea. J. Korean Public Health Assoc. 10: 37-44.

Lee, K.W., H.C. Kim, S.H. Lee, G.W. Korch and T.A. Klein. 1996. [Susceptibility and resistance to diagnostic doses of insecticides on vector and nuisance mosquitoes in Korea.] Korean J. Entomol. 26: 249-256.

Lee, Y.K., J.W. Kim and H.R. Lee. 1994. [Resistance development and cross-resistance of chlorpyrifos, dichlorvos and permethrin-selected house fly (*Musca domestica* L.).] Korean J. Applied Entomol. 33: 166-172.

Shim, J.C., H.K. Hong, S.H. Koo and D.K. Lee. 1995. [Susceptibilities of *Anopheles sinensis* larvae (Culicidae, Diptera) to various insecticides.] Korean J. Entomol. 25: 69-76.

Shim, J.C., H.K. Hong and D.K. Lee. 1995. [Susceptibilities of *Culex tritaeniorhynchus* (Culicidae: Diptera) larvae to insecticides.] Korean J. Entomol. 25: 13-20.

Shim, J.C., D.K. Lee and K.W. Lee. 1997. Insecticide susceptibility of German cockroaches (Blattaria: Blattellidae) in Seoul. Korean J. Entomol. 27: 73-77.

Taiwan

Chao, L.C., S.C. Liao, and W.C.J. Maa. 1993. [Resistance of housefly, *Musca domestica* L., to dichlorvos, malathion, pirimiphos-methyl and propoxur in Lo-tung area.] Chinese J. Entomol. 13: 17-25.

Hou, F.N. and K.H. Lu. 1987. [Studies on susceptibility of the mosquito, *Culex quinquefasciatus* to insecticides in Taiwan.] Taiwan Environ. Sanit. 19: 87-93.

Liao, S.C. and E.L. Hsu. 1996. [Resistance mechanisms of houseflies to dichlorvos and pirimiphos-methyl in three areas of northern Taiwan.] Chinese J. Entomol. 16: 13-23.

Wang, T.C., H.L. Kao and K.S. Kung. 1985. Propoxur resistance of the housefly, *Musca domestica* L., in Taichung. Bull. Inst. Zool. Acad. Sin. 24: 139-146.

Weng, M.H., J.C. Lien, Y.M. Wang, H.L. Wu and C. Chin. 1997. Susceptibility of three laboratory strains of *Aedes albopictus* (Diptera: Culicidae) to Japanese encephalitis virus from Taiwan. J. Med. Entomol. 34: 745-747.

***** Only papers published in the 20 years prior to the preparation of this document are included. Many of these articles describe tests on insect populations that were found to be susceptible or contain general discussions about pesticide resistance in East Asia.

Appendix C
Sources of Snake Antivenins

1	Perusahaam Negara Biofarms 9, Jalan Pasteur Bandung, Indonesia
2	Behring Institut, Behringwerke AG, D3550 Marburg (Lahn), Postfach 167, Germany. Telephone: (06421) 39-0. Telefax: (06421) 660064. Telex: 482320-02
3	Institute of Epidemiology and Microbiology, Sofia, Bulgaria
4	Shanghai Vaccine and Serum Institute, 1262 Yang An Road (W), Shanghai, PRC
5	Commonwealth Serum Laboratories, 45 Poplar Road, Parkville, Victoria 3052, Australia Telegram: “SERUMS,” Melbourne Telex: AA32789, Telephone: 387-1066
6	Foreign Trade Company, Ltd., Kodandaka, 46 Prague 10, Czech Republic
7	Fitzsimmons Snake Park, Box 1, Snell Park, Durban, South Africa
8	Haffkine Bio-pharmaceutical Corporation, Ltd., Parel, Bombay, India
9	Chiba Serum Institute, 2-6-1 Konodai, Ichikawa, Chiba Prefecture, Japan
10	Institut d’État des Serums et Vaccins Razi, P.O. Box 656, Tehran, Iran
11	Central Research Institute, Kasauli (Simia Hills), (H.P.) India
12	Kitasato Institute, 5-9-1 Shirokane, Minato-ku, Tokyo, Japan
13	The Chemo-Sero Therapeutic Research Institute, Kumamoto, 860 Kyushu, Japan
14	National Institute of Health, Biological Production Division, Islamabad, Pakistan. Telex: 5811-NAIB-PK, Telephone: 820797, 827761
15	Research Institute For Microbial Diseases, Osaka University, 3-1 Yamadoaka, Suite 565, Osaka, Japan, Telephone: (06) 877-5121
16	Institut Pasteur Production, 3 Boulevard Raymond Poincaré, 92430-Mames la Coquette, France. Telephone: (1) 47.41.79.22, Telex: PASTVAC206464F
17	Institut Pasteur d’Algérie Docteur Laveran, Algiers, Algeria
18	Industrial and Pharmaceutical Corporation, Rangoon, Burma
19	Rogoff Medical Research Institute, Beillinson Medical Center, Tel-Aviv, Israel
20	South African Institute for Medical Research, P.O. Box 1036, Johannesburg 2000, Republic of South Africa. Telegraph: “BACTERIA”, Telephone: 724-1781
21	Instituto Sieroterapica e Vaccinogeno Toscano “Sclavo”, Via Fiorentina 1, 53100 Siena, Italy.
22	National Institute of Preventive Medicine, 161 Kun-Yang St., Nan-Kang, Taipei, Taiwan
23	Takeda Chemical Industries, Ltd., Osaka, Japan
24	Research Institute of Vaccine and Serum, Ministry of Public Health U.I. Kafanova, 93 Tashkent, USSR
25	Red Cross Society, Queen Saovabha Memorial Institute, Rama 4 Road, Bangkok, Thailand 26
26	Twyford Pharmaceutical Services Deutschland, GmbH, Postfach 2108 05, D-6700 Ludwigshafen am Rhein, Germany
27	Institute of Immunology, Rockefellerova 2, Zagreb, Yugoslavia

Appendix D
Selected List of Taxonomic Papers and Identification Keys*
General

Yu, Y.X. 1990. Contributions to blood-sucking Diptera insects. Vol I. Sci. Tech. Press, Shanghai, 125pp.

Yu, Y.X. 1990. Contributions to blood-sucking Diptera insects. Vol. II. Sci. Tech. Press, Shanghai, 118 pp.

Yu, Y.X. 1991. Contributions to blood-sucking Diptera insects. Vol. III. Sci. Tech. Press, Shanghai, 227 pp.

Ceratopogonidae

Atchley, W.R., W.W. Wirth and C.T. Gaskins. 1981. A bibliography and keyword index of the biting midges (Diptera: Ceratopogonidae). USDA Sci. Educ. Admin. Bibliogr. Lit. Agric. No. 13: 1-544.

Hubert, A.A. 1961. Key to the *Culicoides* of Okinawa and the description of two new species (Diptera, Ceratopogonidae). Proc. Entomol. Soc. Wash. 63: 235-239.*

Kitaoka, S. 1984. Japanese *Culicoides* (Diptera: Ceratopogonidae) and keys for the species. I. Bull. Nat. Inst. Animal. Hlth. No. 87: 73-89.**

Kitaoka, S. 1984. Japanese *Culicoides* (Diptera: Ceratopogonidae) and keys for the species. II. Bull. Nat. Inst. Animal. Hlth. No. 87: 91-107.**

Lee, T.S. 1979. [Biting midges of Tibet, China (Diptera: Ceratopogonidae).] Acta Entomol. Sin. 22: 98-107.**

Li, T. S. 1979. [Biting midges of Tibet, China (Diptera, Ceratopogonidae).] Acta Entomol. Sin. 22: 98-107.**

Lien, J.C. 1989. Taxonomic and ecological studies on the biting midges of the subgenus *Lasiohelea*, genus *Forcipomyia*. J. Taiwan Mus. 42: 37-77.

Lien, J.C., C.C. Lin and C. Chin. 1996. Biting midges of the genus *Culicoides* (Diptera, Ceratopogonidae) from Kinmen Island (Quemoy). J. Taiwan Mus. 49: 117-135.**

Lien, J.C. and C.C. Lin. 1998. A revision of the genus *Culicoides* in Taiwan. Part II. Subgenus *Avaritia* (Diptera, Ceratopogonidae). J. Taiwan Mus. 51: 21-49.**

Lien, J.C., M.H. Weng and C.C. Lin. 1997. A revision of the genus *Culicoides* in Taiwan. Part I. Subgenus *Trithecoides* (Diptera, Ceratopogonidae) J. Taiwan Mus. 50: 155-187.

Lien, J.C., C.C. Lin and M.H. Weng. 1998. A revision of the genus *Culicoides* in Taiwan. Part III. Subgenera *Culicoides* Latreille 1809, *Haemophoructus* Macfie 1925, and *Monoculicoides* Khalaf 1954 (Diptera, Ceratopogonidae). J. Taiwan Mus. 51: 33-70.*****

Liu, G.P. 1989. [Morphological description of pupae of nine species of *Culicoides* Latreille in northeastern China (Diptera: Ceratopogonidae).] Acta Entomol. Sin. 32: 235-241.*****

Liu, J.H. and Y.X. Yu. 1997. New species and new records of the genus *Forcipomyia* subgenus *Microhelea* (Diptera: Ceratopogonidae) from China. Entomol. Sin. 4: 18-29.*****

Liu, Z. 1990. [A study on *Leptoconops* in north-western China (Diptera: Ceratopogonidae).] Sci. Tech. Press, Shanghai, 55pp.*****

McDonald, J.L. 1972. Female *Culicoides* of Taiwan with descriptions of new species (Diptera: Ceratopogonidae). J. Med. Entomol. 9: 396-417.

McDonald, J.L. 1973. Female *Culicoides* of Okinawa with descriptions of new species (Diptera: Ceratopogonidae). J. Med. Entomol. 10: 633-648.*****

Qu, F.Y., Y.J. Zhang and W. Ke. 1994. The *Culicoides* (Diptera: Ceratopogonidae) of Hainan Province. Acta Entomol. Sin. 37: 107-111.

Szadziewski, R. and P. Havelka. 1984. A review of the Palearctic biting midges of the subgenus *Brachypogon* (s. str.) (Diptera, Ceratopogonidae). Pol. Pismo Entomol. 54: 341-358.*****

Tokunaga, M. 1962. Biting midges of the Ryukyu Islands (Diptera, Ceratopogonidae). Pac. Insects 4: 153-217.*****

Wada, Y. 1986. The revision of the *claggi* group of the genus *Culicoides* distributed in Japan, with a description of a new species. Jap. J. Sanit. Zool. 37: 141-152.*****

Wada, Y. 1990. The *verbosus* group of the genus *Culicoides* Latreille (Diptera: Ceratopogonidae) in Japan, with descriptions of three new species and one hitherto unknown male. Trop. Med. 32: 49-72.*****

Wada, Y., I. Miyagi, M. Takagi and Y. Tsuda. 1996. An annotated list of *Culicoides* biting midges in Yaeyama Islands in the southwestern part of Japan (Diptera: Ceratopogonidae). Trop. Med. 38: 61-68.

Wirth, W.W. 1973. Family Ceratopogonidae. pp. 346-388. *In*: A catalog of the Diptera of the Oriental region. Volume I. Suborder Nematocera. M.D. Delfinado (ed.). Univ. Press Hawaii, Honolulu.

Wirth, W.W., P.P. Choudhuri and S.K. Dasgupta. 1985. Descriptive notes and new Asian distribution in the *chaetophthalmus* group of the blood-sucking midge genus *Culicoides* (Diptera: Ceratopogonidae). Orient. Insects 19: 103-109.*

Wirth, W.W. and A.A. Hubert. 1989. The *Culicoides* of Southeast Asia (Diptera: Ceratopogonidae). Mem. Am. Entomol. Inst. No.44: 1-511.*****

Chiggers

Hasegawa, H., M. Otsuru and M. Fuji. 1990. Surveys on vector mites of tsutsugamushi disease in Taiwan and the Ryukyu Islands. Jap. J. Sanit. Zool. 412: 235-246.

Ree, H. I. 1989. Fauna of Trombiculidae and Leeuwenhoekiidae in Korea. Yonsei Rep. Trop. Med. 20: 90-93.

Ree, H. I. 1990. Fauna and key to the chigger mites of Korea (Acarina: Trombiculidae and Leeuwenhoekiidae). Korean J. Syst. Zool. 6: 57-70*****

Wang, D.Q. and Z.Z. Yu. 1992. Chigger mites of the genus *Leptotrombidium*: key to species and their distribution in China. Med. Vet. Entomol. 6: 389-395.*****

Wen, T. 1984. [Sand mites of China (Acariformes: Trombiculidae and Leeuwenhoekiidae).] Xue Liun Publ. House, Shanghai, 370 pp.*****

Cimicidae

Ryckman, R.E., D.G. Bentley and E.F. Archbold. 1981. The Cimicidae of the Americas and Oceanic Islands, a checklist and bibliography. Bull. Soc. Vector Ecol. 6: 93-142.

Culicidae

Chau, G.R. 1982. An illustrated guide to the identification of the mosquitoes of Hong Kong. Urban Counc., Hong Kong, 53 pp.*****

DeMeillon, B. and E.L. Peyton. 1975. Southeast Asia mosquito project. Smithsonian Inst., Wash., DC Fin. Rep. Oct 64-May 74, 34pp.

Dobrotovsky, N. 1971. The genus *Culiseta* Felt in Southeast Asia. Contrib. Am. Entomol. Inst. 7: 38-61.*

Gaffigan, T.V. and R.A. Ward. 1985. Index to the second supplement to "A catalog of the mosquitoes of the world (Diptera: Culicidae)." Mosq. Syst. 17: 52-63.

Gong, Z. 1995. Studies on the genus *Topomyia* of China (Diptera: Culicidae). Acta Entomol. Sin. 38: 475-485.*****

Huang, Y.M. 1979. Medical entomology studies. XI. The subgenus *Stegomyia* of *Aedes* in the Oriental region with keys to the species (Diptera: Culicidae). Contrib. Am. Entomol. Inst. 15: 1-79.*****

Hubert, A.A. and K. Tanaka. 1972. Mosquitoes of Japan, Korea, and the Ryukyu Islands. U.S. Army Med. Lab. Pacific, Japan Annu. Res. Prog. Rep. 1 Jul 71-30 Jun 72: 15-24.

Hubert, A.A., E.S. Saugstad and K. Tanaka. 1973. Mosquitoes of Japan, including the Ryukyus, and Korea. U.S. Army Med. Lab. Pacific, Japan Annu. Res. Prog. Rep. 1 Jul 72-30 Jun 73: 5-14.

Intermill, R.W. 1971. Illustrated key to mosquitoes of Okinawa. U.S. Army Med. Cent. Entomol. Div., Ryukyu Isl., 76 pp.*****

Ishii, T. 1977. On the *Culex pipiens* group in Japan. Part III. A historical review of its research. 1. Names adopted for *Culex pipiens pallens* Coquillett (Diptera, Culicidae). Univ. Tokushima J. Sci. 10: 31-57.

Ishii, T. 1983. On the *Culex pipiens* group in Japan. Part III. A historical review of its research. 7. Review of the larval characters. J. Sci. Coll. Gen. Educ. Univ. Tokushima 16: 27-109.

Knight, K.L. 1978. Supplement to "A catalog of the mosquitoes of the world (Diptera: Culicidae)." Thomas Say Found., Entomol. Soc. Am., Vol. 6, 107 pp.

Knight, K.L. and A. Stone. 1977. A catalog of the mosquitoes of the world (Diptera: Culicidae). 2nd ed. Thomas Say Found., Entomol. Soc. Am., Vol. 6, 611 pp.

Lee, K.W. 1987. [Checklist of mosquitoes (Culicidae) in Korea.] Korean J. Parasitol. 25: 207-209.

Lee, K.W. and P.J. Egan. 1985. Illustrated taxonomic keys to genera and species of female mosquitoes of Korea. Part I. U.S. Army 5th Prev. Med. Unit, Korea: 34pp.*****

Lee, K.W. and T. Zorka. 1991. Illustrated taxonomic keys to genera and species of mosquito larvae of Korea. 2nd ed. Part II. US Army 5th Prev. Med. Unit, Korea: 29pp.*****

Lu, B. and H. Chen. 1983. [The pupal characters and key to subfamilies and genera of pupae of Chinese mosquitoes (Diptera: Culicidae).] Entomotaxonomia 5: 83-90.*****

Lu, B., S. Ji and R.A. Ward. 1989. New mosquitoes in China added to the second supplement of the world catalog (Diptera: Culicidae). Mosq. Syst. 21: 11-15.

Lu, B. L. and Z. D. Gong. 1986. Studies on the genus *Heizmannia* of China with descriptions of two species (Diptera: Culicidae). Acta Entomol. Sin. 29: 181-189.*****

Mattingly, P. 1971. Contributions to the mosquito fauna of Southeast Asia. XIII. Illustrated keys to the genera of mosquitoes (Diptera: Culicidae). Contrib. Am. Entomol. Inst. 7: 1-84.*****

Ramos, H.C., H. Ribeiro, M.T. Novo and E.R. Easton. 1997. [The mosquitoes of Macau (Diptera: Culicidae).] Sociedade Portuguesa de Entomologia, Lisboa, Portugal, 201 pp.*****

Reuben, R., S.C. Tewari and J. Hiriyan. 1994. Illustrated keys to species of *Culex* (*Culex*) associated with Japanese encephalitis in Southeast Asia (Diptera: Culicidae). Mosq. Syst. 26: 75-96.*****

Sirivanakarn, S. 1976. Medical entomology studies. III. A revision of the subgenus *Culex* in the Oriental region (Diptera: Culicidae). Contrib. Am. Entomol. Inst. 12: 1-272.*

Tanaka, K., K. Mizusawa and E.S. Saugstad. 1979. A revision of the adult and larval mosquitoes of Japan (including the Ryukyu Archipelago and the Ogasawara Islands) and Korea (Diptera: Culicidae). Contrib. Am. Entomol. Inst. 16: 1-987.*****

Tanaka, K., E.S. Saugstad and K. Mizusawa. 1975. Mosquitoes of the Ryukyu Archipelago (Diptera: Culicidae). Mosq. Syst. 7: 207-233.

Toma, T. and I. Miyagi. 1986. The mosquito fauna of the Ryukyu Archipelago with identification keys, pupal descriptions and notes on biology, medical importance and distribution. Mosq. Syst. 18; 1-109.*****

Toma, T., I. Miyagi and Y. Watakuyama. 1988. Morphological keys to medically important mosquitoes of the Ryukyu Islands with notes on ecology. IV. Key to the subgenera and species of *Culex*. Trop. Cancer 21: 51-60.*****

Tyson, W. 1970. Contributions to the mosquito fauna of Southeast Asia. VIII. Genus *Aedes*, subgenus *Mucidu* Theobald in Southeast Asia. Contrib. Am. Entomol. Inst. 6: 29-80.*****

Ward, R.A. 1984. Second supplement to "A catalog of the mosquitoes of the world (Diptera: Culicidae)." Mosq. Syst. 16: 227-270.

Ward, R.A. 1992. Third Supplement to "A catalog of the mosquitoes of the world (Diptera: Culicidae)." Mosq. Syst. 24: 177-230.

Zavortink, T. 1971. The genus *Orthopodomyia* in Southeast Asia. Contrib. Am. Entomol. Inst. 7: 1-37.

Other Diptera

Duckhouse, D.A. 1973. Family Psychodidae. pp. 226-244. *In*: A catalog of the Diptera of the Oriental region. Volume I. Suborder Nematocera. M.D. Delfinado (ed.). Univ. Press Hawaii, Honolulu.

Hayashi, T. 1986. Studies on the sphaerocerid flies of synanthropy and hygienic importance in Japan (Diptera). I. The key to species of flies. Jap. J. Sanit. Zool. 37: 113-120.*****

Hayashi, T. 1986. Studies on the sphaerocerid flies of synanthropy and hygienic importance in Japan (Diptera). II. Records of the forty species. Jap. J. Sanit. Zool. 37: 193-204.

Iwasa, M. 1987. The Sepsidae from Taiwan. Sieboldia Acta Biol., Fukuoka Suppl. Mar.: 1-9.*****

James, M.T. 1977. Family Calliphoridae. pp. 526-556. *In*: Volume III. Suborder Cyclorrhapha (excluding division Aschiza). M.D. Delfinado (ed.). Univ. Press Hawaii, Honolulu.

Kurahashi, H. 1975. Studies on the calypterate muscoid flies from Japan. XI. Subfamily Arginae (Diptera, Sarcophagidae). Kontyu 43: 202-213.*****

Nishida, K. 1975. Six new and one newly recorded species of the genus *Fannia* (Diptera, Muscidae) from Taiwan, with a key to species. Kontyu 43: 364-380.*****

Park, S.H. 1977. Studies on flies in Korea. I. Taxonomic studies on calliphorid flies (Diptera). Bull. Tokyo Med. Dent. Univ. 24: 189-208.*****

Park, S.H. 1977. Studies on flies in Korea. II. Taxonomical studies on sarcophagid flies (Diptera). Bull. Tokyo Med. Dent. Univ. 24: 249-284.*****

Park, S.H. 1978. [Studies on flies in Korea. 13. On the 17 species of sarcophagid flies (Diptera, Sarcophagidae).] Korean J. Entomol. 8: 1-6.*****

Park, S.H. 1978. Studies on flies in Korea. III. Taxonomic studies on muscid flies (Diptera: Muscidae). Bull. Tokyo Med. Dent. Univ. 25: 17-43.*****

Pont, A.C. 1977. Family Muscidae. pp. 451-523 *In*: A catalog of the Diptera of the Oriental region. Volume III. Suborder Cyclorrhapha (excluding division Aschiza). M.D. Delfinado (ed.). Univ. Press Hawaii, Honolulu.

Pont, A.C. 1977. Family Oestridae. pp. 700-702. *In*: A catalog of the Diptera of the Oriental region. Volume III. Suborder Cyclorrhapha (excluding division Aschiza). M.D. Delfinado (ed.). Univ. Press Hawaii, Honolulu.

Rohdendorf, B.B. and Y.G. Verves. 1978. Sarcophaginae (Diptera, Sarcophagidae) from Mongolia. Ann. Hist. Nat. Mus. Natl. Hung., Budapest 70: 241-258.

Shinonaga, S. and R. Kano. 1971. Muscidae (Insecta: Diptera). Vol. I. *In*: Fauna Japonica. Biogeogr. Soc. Japan, Tokyo, 242 pp.

Shinonaga, S. and R. Kano. 1987. Studies on Muscidae from Taiwan (Diptera). Part 1. Muscinae and Stomoxyinae. Sieboldia Acta Biol., Fukuoka Suppl. Mar.: 31-46.*****

Sifner, F. 1975. [The Sarcophagidae (Diptera) of Mongolia.] Ann. Hist. Nat. Mus. Natl. Hung., Budapest 67: 219-227.

Sublette, J.E. and M.F. Sublette. 1973. Family Chironomidae. pp. 389-422. *In*: A catalog of the Diptera of the Oriental region. Volume I. Suborder Nematocera. M.D. Delfinado (ed.). Univ. Press Hawaii, Honolulu.

Sugiyama, E., S. Shinonaga and R. Kano. 1987. Sarcophaginae in Taiwan (Diptera: Sarcophagidae). Sieboldia Acta Biol., Fukuoka Suppl. Mar.: 61-81.*****

Mammalia

Jones, G.S. 1971. A key to the mammals of Taiwan. Chin. J. Microbiol. 4: 267-278.*****

Nowak, R.M. (ed.) 1999. Walker's Mammals of the World. 6th ed., John Hopkins University Press, Baltimore, 1936 pp.

Wilson, D.E. and D.M. Reeder. 1993. Mammal Species of the World: a Taxonomic and Geographic Reference. 2nd ed., Smithsonian Institution Press, Washington, DC, 1,206 pp.

Psychodidae

Alves-Pires, C., H.C. Ramos, H. Ribeiro and E.R. Easton. 1996. Occurrence of *Sergentomyia* (*Parrotomyia*) *barraudi* (Sinton, 1929) in Macau. Parasite 3: 91-93.*****

Cates, M.D. and J.C. Lien. 1970. The *Phlebotomus* of Taiwan. J. Med. Entomol. 7: 529-543.*****

Leng, Y.J. 1988. A review of phlebotomine sandflies and their transmission of leishmaniasis in China. Jap. J. Sanit. Zool. 39: 323-337.

Leng, Y.J. 1991. Classification and geographical distribution of phlebotomine sandflies in China. Annu. Bull. Soc. Parasitol. 93: 11-13.

Leng, Y.J. 1997. Eighty-year research of phlebotomine sandflies (Diptera: Psychodidae) in China (1915-1995). I. Taxonomy and zoogeographical distribution. Parasite 4: 107-126.

Leng, Y.J. and Yin, Z.C. 1983. The taxonomy of phlebotomine sandflies (Diptera: Psychodidae) of Sichuan Province, China, with descriptions of two species, *Phlebotomus* (*Adlerius*) *sichuanensis* n. sp. and *Sergentomyia* (*Nephlebotomus*) *zhengjiani* n. sp. Ann. Trop. Med. Parasitol. 77: 421-431.*****

Leng, Y.J. and L.M. Zhang. 1993. Checklist and geographical distribution of phlebotomine sandflies in China. Ann. Trop. Med. Parasitol. 87: 83-94.

Lewis, D.J. 1973. Family Phlebotomidae. pp. 245-254 *In*: A catalog of the Diptera of the Oriental region. Volume I. Suborder Nematocera. M.D. Delfinado (ed.). Univ. Press Hawaii, Honolulu.

Lewis, D.J. 1978. The phlebotomine sandflies (Diptera : Psychodidae) of the Oriental region. Bull. Brit. Mus. Nat. History, Entomol. Ser. 37: 1-343.*

Lewis, D.J. 1982. A taxonomic review of the genus *Phlebotomus* (Diptera: Psychodidae). Bull. Brit. Mus. Nat. History, Entomol. Ser. 45: 1- 209.*

Lewis, D.J. 1987. Phlebotomine sandflies (Diptera: Psychodidae) from the Oriental region. Syst. Entomol. 12: 163-180.*

Reptiles

Harding, K.A. and K.R.G. Welch. 1980. Venomous snakes of the world: a checklist. Pergamon Press, Oxford, 188 pp.

McDiarmid, R., J. Campbell and T. Toure. 1999. Snake species of the world. A taxonomic and geographic reference. Volume I. The Herpetologist's League, Washington, DC, 511 pp.

Poisonous snakes of the world, a manual for use by U.S. amphibious forces. 1966. NAVMED P-5099, BUMED, Department of the Navy, U.S. Gov. Print. Off., 212 pp.*****

Welch, K.R.G. 1988. Snakes of the Orient: a checklist. Robert E. Krieger Publ. Co., Malabar, FL, 188pp.

Wuster, W. and R.S. Thorpe. 1991. Asiatic cobras: systematics and snakebite. Experientia 47: 205-209.

Wuster, W. and R.S. Thorpe. 1992. Asiatic cobras: population systematics of the *Naja naja* species complex (Serpentes: Elapidae) in India and central Asia. Herpetologica 48: 69-85.

Scorpions

Couzjin, H.W.C. 1981. Revision of the genus *Heterometrus* Hemprich & Ehrenberg (Scorpionidae, Arachnidea). Zool. Verhandelingen No. 184: 1196 pp.*****

El Hennawy, H.K. and H.K. El Hennawy. 1990. Key to scorpion families (Arachnida: Scorpionida). Serket 2: 14-19.*

Keegan, H.L. 1980. Scorpions of medical importance. Univ. Press Miss., Jackson, 140 pp.

Sissom, W.D. 1990. Systematics, biogeography, and paleontology. pp. 64-136 *In:* The biology of scorpions, G.A. Polis (ed.). Stanford Univ. Press.*

Stahnke, H.L. 1972. A key to the genera of Buthidae (Scopionida). Ent. News 83: 121-133.*

Simuliidae

Crosskey, R.W. 1973. Family Simuliidae. pp. 423-430. *In*: A catalog of the Diptera of the Oriental region. Volume I. Suborder Nematocera. M.D. Delfinado (ed.). Univ. Press Hawaii, Honolulu.

Halgos, J. and L. Jedlicka. 1985. Notes on some black flies from desert and semidesert regions of Mongolian People's Republic (Diptera: Simulidae). Acta Fac. Rerum Nat. Univ. Comenianae Zool. 28: 21-25.

Kim, K.C. and R.W. Merritt. 1987. Black flies - ecology, population management, and annotated world list. Penn. State Univ., University Park, 543 pp.

Takaoka, H. 1974. Blackflies from Cheju Island in Korea with the description of *Simulium* (*Eusimulium*) *subcostatum chejuense* n. sp. (Diptera, Simuliidae). Jap. J. Sanit. Zool. 25:141-46.

Takaoka, H. 1977. Studies on black flies of the Nansei Islands, Japan (Diptera, Simuliidae). IV. Keys to females, males, pupae and larvae of all the 18 species of the genus *Simulium* of the Nansei Islands. Jap. J. Sanit. Zool. 28: 219-224.*****

Takaoka, H. 1979. The black flies of Taiwan (Diptera: Simuliidae). Pac. Insects 20: 365-403.*****

Takaoka, H. and T. Okazawa. 1988. [A revised list of Japanese blackflies (Simuliidae).] Jap. J. Sanit. Zool. 39: 97-103.

Siphonaptera

Adams, N.E. and R.E. Lewis. 1985. An annotated catalogue of primary types of Siphonaptera in the National Museum of Natural History, Smithsonian Institution. Smithson. Contri. Zool. No. 56: 1-86.

Lewis, R.E. 1988. The status of the names of some fleas from China. J. Kans. Entomol. Soc. 61: 140-141.

Lewis, R.E. 1990. The Ceratophyllidae: currently accepted valid taxa (Insecta: Siphonaptera). Theses Zoologicae, volume 13. R. Fricke (ed.). Koeltz Scientific Books. Koenigstein, Germany. 267 pp.

Lewis, R.E. and J.H. Lewis. 1989. Catalogue of invalid genus-group and species-group names in the Siphonaptera (Insecta). Theses Zoologicae, Volume 11. R. Fricke (ed.). Koeltz Scientific Books. Koenigstein, Germany. 263 pp.

Liu, C.Y. and H.Y. Wu. 1979. [A preliminary discussion on the faunal distribution and phylogeny of the fleas of China.] Acta Zootaxon. Sin. 4: 99-112.

Krumpal, M., M. Kiefer and D. Cyprich. 1985. The fleas (Siphonaptera) of squirrels (*Citellus* spp.) in Mongolia. Acta Fac. Rerum Nat. Univ. Comenianae Zool. 28: 57-75.

Traub, R., M. Rothschild and J.F. Haddow. 1983. The Rothschild collection of fleas. The Ceratophyllidae: Key to the genera and host relationships. With notes on their evolution, zoogeography and medical importance. Privately published by M. Rothschild and R. Traub. Distributed by Academic Press. 288 pp.

Wang, D.Q. 1988. [A tentative classification of flea larvae (Siphonaptera).] Acta Entomol. Sin. 31: 326-331.*****

Tabanidae

Hayakawa, H. 1985. A key to the females of Japanese tabanid flies with a checklist of all species and subspecies (Diptera, Tabanidae). Jap. J. Sanit. Zool. 36: 15-23.*****

Kozanek, M. and H. Takahasi. 1993. Contribution to the knowledge of horseflies (Diptera: Tabanidae) from North Korea. Jap. J. Sanit. Zool. 44: 287-289.

Murdock, W.P. 1969. The female Tabanidae of Japan, Korea and Manchuria. Mem. Entomol. Soc. Wash. No. 6, 230 pp.

Stone, A. 1983. Family Tabanidae. pp. 43-81. *In*: Volume II. Suborder Brachycera through division Aschiza, suborder Cyclorrhapha. M.D. Delfinado (ed.). Univ. Press Hawaii, Honolulu.

Wang, Z.M. 1978. [On the blood-sucking tabanids from south China (Diptera: Tabanidae).] Acta Entomol. Sin. 20: 106-118.*****

Wang, Z.M. 1985. [The horse flies of Xinjiang autonomous region (Diptera: Tabanidae).] Acta Entomol. Sin. 28: 425-429.*****

Xie, B.Q. 1992. [The flea fauna and the flea species in relation to plague in Yunnan Province, China.] Endem. Dis. Bull. 7: 45-50.

Ticks (Ixodidae, Argasidae)

Balashov, Yu. S. 1972. Bloodsucking ticks (Ixodoidea) - vectors of diseases of man and animals. Misc. Publ. Entomol. Soc. Amer. 8: 1-376.

Teng, K.F. 1982. The geographic distribution of the genus *Dermacentor* in China. Sinozoologia 2: 211-216.

Teng, K.F. 1986. Studies on the genus *Ixodes* in China (Acari: Ixodidae) Acta Zootaxon. Sin. 11: 46-53.*****

Yamaguti, N. 1971. Ticks of Japan, Korea, and the Ryukyu Islands. Brigham Young Univ. Sci. Bull., Biol. Ser. 15: 1-226.

*****Papers marked with an asterisk include a taxonomic key for identification of species. References without identification keys usually contain a checklist of species known from a given geographic area or a list of species collected during extensive surveys of an area.

Appendix E
Personal Protective Measures

Personal protective measures are the first line of defense against arthropod-borne disease and, in some cases, may be the only protection for deployed military personnel. Proper wearing of the uniform and appropriate use of repellents can provide high levels of protection against blood-sucking arthropods. The uniform fabric provides a significant mechanical barrier to mosquitoes and other blood-sucking insects. Therefore, the uniform should be worn to cover as much skin as possible if weather and physical activity permit. When personnel are operating in tick-infested areas, they should tuck their pant legs into their boots to prevent access to the skin by ticks, chiggers, and other crawling arthropods. They should also check themselves frequently for ticks and immediately remove any that are found. If a tick has attached, seek assistance from medical authorities for proper removal or follow these guidelines from TIM 36, Section IX A.

1. **Grasp the tick's mouthparts** where they enter the skin, using pointed tweezers.

2. **Pull out** slowly and steadily with gentle force.

    a. Pull in the reverse of the direction in which the mouthparts are inserted, as you would for a splinter.

    b. **Be patient –** The long, central mouthpart (called the hypostome) is inserted in the skin. It is covered with sharp barbs, sometimes making removal difficult and time consuming.

    c. Many hard ticks secrete a cement-like substance during feeding. This material helps secure their mouthparts firmly in the flesh and adds to the difficulty of removal.

    d. It is important to continue to pull steadily until the tick can be eased out of the skin.

    e. **Do not** pull back sharply, as this may tear the mouthparts from the body of the tick, leaving them embedded in the skin. If this happens, don't panic. Embedded mouthparts are comparable to having a splinter in your skin. However, to prevent secondary infection, it is best to remove them. Seek medical assistance if necessary.

    f. **Do not** squeeze or crush the body of the tick because this may force infective body fluids through the mouthparts and into the wound.

g. **Do not** apply substances like petroleum jelly, fingernail polish remover, repellent pesticides, or a lighted match to the tick while it is attached. These materials are either ineffective or, worse, may agitate the tick and cause it to salivate or regurgitate infective fluid into the wound site.

h. If tweezers are not available, grasp the tick's mouthparts between your fingernails, and remove the tick carefully by hand. Be sure to wash your hands -- especially under your fingernails -- to prevent possible contamination by infective material from the tick.

3. Following removal of the tick, **wash the wound** (and your hands) with soap and water and **apply an antiseptic**.

4. **Save the tick** in a jar, vial, small plastic bag, or other container for identification, should you later develop disease symptoms. Preserve the tick by either adding some alcohol to the jar or by keeping it in a freezer. Storing a tick in water will not preserve it. Identification of the tick will help the physician's diagnosis and treatment, since many tick-borne diseases are transmitted only by certain species.

5. **Discard** the tick after one month; all known tick-borne diseases will generally display symptoms within this time period.

Newly developed repellents provide military personnel with unprecedented levels of protection. An aerosol formulation of permethrin (NSN 6840-01-278-1336) can be applied to the uniform according to label directions, but not to the skin. This will impart both repellent and insecticidal properties to the uniform material that will be retained through numerous washings. An extended formulation lotion of N, N-diethyl-m-toluamide (DEET) (NSN 6840-01-284-3982) has been developed to replace the 2 oz. bottles of 75% deet in alcohol. This lotion contains 33% active ingredient. It is less irritating to the skin, has less odor and is generally more acceptable to the user. A properly worn Battle Dress Uniform (BDU) impregnated with permethrin, combined with use of extended duration DEET on exposed skin, has been demonstrated to provide nearly 100% protection against a variety of blood-sucking arthropods. This dual strategy is termed the DoD ARTHROPOD REPELLENT SYSTEM. In addition, permethrin may be applied to bednets, tents, and other field items as appropriate. Complete details regarding these and other personal protective measures are provided in TIM 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance (2001).

Appendix F.
Bioscience and State Department Contacts in East Asia.

1. **Regional Contacts.**

World Health Organization (WHO) Phone: +00-41-22-791-2111
Headquarters Office in Geneva (HQ) FAX: +00-41-22-791-3111
Avenue Appia 20
1211 Geneva 27, SWITZERLAND Website: < http://www.who.int/home/hq.html >

World Health Organization Phone: 1 (212) 963-4388
Office at the United Nations (WUN) FAX: 1 (212) 223-2920
2, United Nations Plaza
DC - 2 Building e-mail: < verano@un.org >
Rooms 0956 to 0976
New York, NY 10017

World Health Organization Phone: (00632) 528-80-01
Regional Office for the Western Pacific (WPRO) FAX: (00632) 521-10-36
P.O. Box 2932 *or* (00632) 536-02-79
1000 Manila, Philippines e-mail: < Postmaster@who.org.ph" >
Website: < http://www.wpro.who.int/ >

[for: **China (including Hong Kong and Macau), Japan, Mongolia, and the Republic of Korea (South Korea)**]
World Health Organization (WHO) Phone: 91-11-331-7804
Regional Office for South-East Asia (SEARO) or 91-11-331-7823
World Health House FAX: 91-11-331-8607
Indraprastha Estate or 91-11-331-7972
Mahatma Gandhi Road e-mail: < postmaster@whosea.org >
New Delhi 110002, INDIA Website: < http://www.whosea.org >

[for: **Democratic People's Republic of Korea** (**North Korea**)]
Centers for Disease Control and Prevention
Division of Quarantine Phone: (404) 639-3311
National Center for Infectious Diseases e-mail: < netinfo@cdc.gov >
1600 Clifton Road, NE Atlanta, GA 30333 U.S.A.
Website:<http://www.cdc.gov/travel/index.htm >

Commander
U.S. Army Medical Component
AFRIMS APO, AP 96546

Phone: 66-2-644-5777 (Thailand)
FAX: 66-2-247-6030 (Thailand)

Commanding Officer
(Jakarta, INDONESIA)
NAMRU-2
Box 3, Unit 8132
APO, AP 96520-8132

Phone: 011-62-21-421-4457
or 011-62-21-421-4463
FAX: 011-62-21-421-4407
(Jakarta, INDONESIA)

2. **Country Contacts.**

a. **China**

Ambassador
3 Xiu Shui Bei Jie
Beijing
CHINA 100600

Phone: (86-10) 6532-3431
FAX: 880-2-883-744

Consulate(s) General in: Guangzhou, Shanghai, Shenyang, Chengdu, & Hong Kong

b. **Hong Kong.**

The U.S. does not have an embassy in Hong Kong. All diplomatic relations are handled through the U.S. Embassy to China and the U.S. Consulate General in Hong Kong.

American Consulate General
Hong Kong
26 Garden Road
HONG KONG

Phone: (852) 2523-9011
FAX: (852) 2845-1598

c. **Japan.**

Ambassador
10-5 Akasaka
1 - Chome,
Minato-ku, Tokyo
107-8420, JAPAN

Phone: (03) 3224-5000
FAX: (03) 3224-5856

Consulate(s) General in: Osaka, Naha, Sapporo, Fukuoka, & Nagoya.

d. **Macau.**

The U.S. and the Chinese Special Administrative Region (SAR) of Macau have no formal diplomatic relations, but informal contact is maintained between Macau and the U.S. Consulate in Hong Kong (see above).

e. **Mongolia.**

Ambassador	Phone: [976] (1) 329095
Micro Region 11, Big Ring Road	
C. P. O. 1021	FAX: [976] (1) 320776
Ulaanbaatar 13	
MONGOLIA	

Mailing address: c/o American Embassy Beijing, Micro Region 11, Big Ring Road,
C.P.O. 1021, Ulaanbaatar 13, PSC 461, Box 300, FPO AP 96521-0002

f. **North Korea.**

The U.S. has no formal diplomatic relations with North Korea. However, North Korea maintains a permanent mission at the UN in New York, and the Swedish embassy in P'yongyang represents the U.S. as consular protecting power.

g. **South Korea.**

Ambassador	Phone: [82] (2) 397-4114
82 Sejong-Ro	FAX: [82] (2) 738-8845
Chongro-ku, Seoul	
REPUBLIC OF KOREA	

h. **Taiwan.**

The U.S. has no formal diplomatic relations with Taiwan. However, Taiwan maintains unofficial commercial and cultural relations with the people of the U.S. through a private agency, the Taipei Economic and Cultural Representative Office (TECRO) in the U.S., with headquarters in Taipei and field offices in Washington, DC, and 12 other U.S. cities. The American Institute in Taiwan (AIT) is a private corporation with headquarters in Rosslyn, VA, phone: (703) 525-8474 and FAX: (703) 841-1385; and offices in Taipei at # 7 Lane 134, Hsin Yi Road, Section 3, Taipei, phone: (886) (2) 2709-2000, FAX: (886) (2) 2702-7675; and at two other sites in Taiwan.

Appendix G
Glossary

acaricide - a substance developed to kill ticks and mites.

adulticide - insecticide used to kill the adult stages of an insect.

anaphylaxis - an unusual and severe allergic reaction of an organism to a foreign protein or other substances.

anthropophilic - the preference of insects and other arthropods to suck blood from humans rather than from animals.

autochthonous - transmission of a disease in the place where the disease occurs.

autogenous - not requiring a bloodmeal to produce eggs.

bionomics - the ecology of an organism.

biotope - a habitat characterized by a particular set of environmental conditions and community of animals and plants.

campestral - relating to fields or open country.

carrier - a person or animal that harbors infectious organisms but is free of clinical disease; generally synonymous with reservoir.

case fatality rate - the percentage of persons diagnosed as having a specific disease who die as a result of that illness within a given period.

cephalothorax - a body region consisting of head and thoracic segments.

cercaria (pl. cercariae) - free-living stage in the life cycle of *Schistosoma* that emerges from snails and infects vertebrate hosts.

chelicerae - a pair of appendages used as mouthparts in arachnids, such as scorpions, spiders, and ticks.

chemoprophylaxis - the administration of a chemical to prevent the development of an infection or the progression of an infection to active disease.

commensal - living in close association with another organism.

crepuscular - the twilight periods of light at dusk and dawn.

delayed contact sensitivity - reaction of skin or other tissue that takes 24 to 48 hours to develop and involves cell-mediated immunity.

diapause - a period of arrested development and reduced metabolic rate, during which growth and metamorphosis cease.

diurnal - activities occurring during the daytime.

ectoparasite - a parasite that lives on the exterior of its host.

endemic - the constant presence of a disease or infection within a given geographic area.

endophagic - an arthropod that prefers to feed indoors.

endophilic - the tendency of arthropods to enter human structures.

enzootic - a disease that primarily infects animals and is present in an animal community at all times.

epidemic - the occurrence of cases of an illness (or an outbreak) that is clearly in excess of normal expectancy.

epizootic - an outbreak of a disease within an animal population.
eutrophic - rich in nutrients; usually applied to aquatic ecosystems.
exophagic - the tendency of an arthropod to feed outdoors.
exophilic - the tendency of blood-sucking arthropods to feed and rest outdoors.
facultative - not obligatory; characterized by the ability to adjust to circumstances.
family - a group of related genera.
focus (pl. foci) - a specific localized area.
genus (pl. genera) - a group of closely related species.
gonotrophic cycle - the time between feeding, egg development and oviposition.
immediate contact sensitivity - reaction of skin or other tissue within minutes after the interaction of a chemical antigen with antibody.
inapparent infection - the presence of infection in a host without clinical symptoms.
incidence - the number of new cases of a specific disease occurring during a certain period of time.
incubation period - the time interval between initial contact with an infectious agent and the first appearance of symptoms associated with the infection.
indigenous - living or occurring naturally in a particular environment or area.
infection rate - the proportion (expressed as a percent) of a vector or host population that is infected.
infective - an organism that can transmit an infectious agent to another individual.
instar - an insect between successive molts.
larva (pl. larvae) - the immature stage, between the egg and pupa of an insect, or the six-legged immature stage of a tick.
larvicide - insecticides used to kill larvae or immature stages of an insect.
larviparous - insects that deposit larvae rather than eggs on a host, food source, or other substrate.
maggot - legless larva of flies (Diptera).
mechanical transmission - the vector transmits the pathogen on contaminated mouthparts, legs, or other body parts, or by passage through the digestive tract without change.
miracidium (pl. miracidia) - ciliated, first larval stage in the life cycle of *Schistosoma* that penetrates and infects a snail, undergoing further development in the snail.
molluscicide - a chemical substance used for the destruction of snails and other molluscs.
myiasis - the invasion of human tissues by fly larvae.
night soil - human excrement used as fertilizer.
nosocomial - originating in a hospital or medical treatment facility.
nulliparous - a female arthropod that has not laid eggs.
nymph - an immature stage of an insect that does not have a pupal stage or an eight-legged immature tick or mite.
obligate - necessary or compulsory; characterized by the ability to survive only in a particular environment.
pandemic - a widespread epidemic disease distributed throughout a region or continent.

parous - a female arthropod that has laid eggs.
pedipalps - the second pair of appendages of an arachnid.
periurban - relating to an area immediately surrounding a city or town.
prevalence - the total number of cases of a disease in existence at a certain time in a designated area.
photoallergy - an increased reactivity of the skin to ultraviolet and/or visible radiation on an immunological basis.
phototoxicity - an increased reactivity of the skin to ultraviolet and/or visible radiation on a nonimmunological basis.
pupa (pl. pupae) - a nonfeeding and usually inactive stage between the larval and adult stage.
quest (questing) - the behavior of ticks waiting for a passing host.
refractory - a host or vector that will not permit development or transmission of a pathogen.
reservoir - any animal, plant or substance in which an infectious agent survives and multiplies.
rodenticide - a chemical substance used to kill rodents, generally through ingestion.
ruminants - relating to a group of even-toed mammals, such as sheep, goats and camels, that chew the cud and have a complex stomach.
sequelae - any aftereffects of disease.
species complex - a group of closely related species, the taxonomic relationships of which are sometimes unclear, making individual species identification difficult.
steppe - a vast, arid and treeless tract found in southeastern Europe or Asia.
sylvatic - related to a woodland or jungle habitat.
synanthropic - animals that live in close association with man.
synergist - a chemical that may have little or no toxicity in itself but, when combined with a pesticide, greatly increases the pesticide’s effectiveness.
transovarial transmission - passage of a pathogen through the ovary to the next generation .
transstadial transmission - passage of a pathogen from one stage of development to another after molting.
ultra low volume (ULV) - the mechanical dispersal of concentrated insecticides in aerosols of extremely small droplets that drift with air currents.
urticaria - a reaction of the skin marked by the appearance of smooth, slightly elevated patches (wheals) that are redder or paler than the surrounding skin and often associated with severe itching.
vector - an organism that transmits a pathogen from one host to another.
vector competence - the relative capability of a vector to permit the development, multiplication and transmission of a pathogen.
vesicant - a blistering agent.
viremia - a virus that is present in the blood.
virulence - the degree of pathogenicity of an infectious agent.
xerophilic - tolerant of dry environments.
zoonosis - an infectious disease of animals transmissible under natural conditions from nonhumans to humans.

zoophilic - the preference of arthropods to feed on animals other than humans.

Appendix H
Internet Websites on Medical Entomology and Vector-borne Diseases

A. Primary Sites.

1. The Armed Forces Pest Management Board's website provides information about the Board as well as Army, Navy and Air Force entomology programs. Users can download Board publications, including Technical Information Memorandums, Disease Vector Ecology Profiles, and Technical Information Bulletins, and search the Defense Pest Management Information Analysis Center's literature database.
   <http://www.afpmb.org/>

2. Emerging diseases website, with current information on disease outbreaks.
   <http://www.fas.org/promed>

3. Iowa State University's comprehensive site on medical entomology, with excellent information on links to over 20 additional sites.
   <http://www.ent.iastate.edu/>

4. WHO disease outbreak information – emerging and communicable disease information from the WHO and its databases. The tropical medicine databases are the most useful for vector-borne diseases. Access can also be obtained to the Weekly Epidemiological Record.
   <http://www.who.int/emc/index.html>

5. The Walter Reed Biosystematic Unit's online information regarding taxonomic keys, diseases transmitted by mosquitoes, and mosquito identification modules.
   <http://wrbu.si.edu/>

6. Centers for Disease Control – information on the CDC's travel alerts, including access to country health profiles, vaccine recommendations, State Department entry requirements, and publications.
   <http://www.cdc.gov/travel/>

7. The National Library of Medicine's biomedical databases, especially Medline. Provides complete references and abstracts to more than 9 million journal articles from biomedical publications.
   <http://www.nlm.nih.gov/>

8. The Malaria Foundation International's site for general resources on malaria available through the worldwide web. Includes references, malaria advisories, and lists of other malaria websites.
<http://www.malaria.org>

9. The WHO site for information on vector-borne diseases, including disease distribution, information on disease outbreaks, travel alerts, WHO research programs, and progress on control.
<http://www.who.ch/>

1. The CDC's site on information available on diseases, as published in the Morbidity and Mortality Weekly Report and other publications including Emerging Infectious Diseases. Includes case definition and disease outbreak information. Provides access to other websites.
<http://www.cdc.gov/epo/mmwr/other/case_def/enceph.html>

2. Information from the University of Florida's website on mosquitoes and other biting flies.
<http://hammock.ifas.ufl.edu/text/ig/8804.html>

3. Information on ticks and other ectoparasites from the University of Rhode Island's Tick Research Laboratory. Includes information on tick-borne diseases, tick images, and links to related sites.
<http://www.riaes.org/resources/ticklab/>

4. Information on plague available from the CDC's Morbidity and Mortality Weekly Report.
<http://www.cdc.gov/epo/mmwr/other/case_def/plague.html>

B. Additional Sites.

1. A list of websites and servers pertaining to entomology from Colorado State University. Over 30 websites are listed.
<http://www.colostate.edu/Depts/Entomology/ent.html>

2. Lyme Disease Network – information on Lyme disease, including research abstracts, treatments for Lyme disease, newsletter, conferences, and professional resources.
<http://www.lymenet.org>

3. The USDA plant database – includes the integrated taxonomic information system.
<http://plants.usda.gov/ >

1. University of Sydney, Medical Entomology – contains information on mosquito keys, fact sheets, and photos of mosquitoes.

<http://medent.usyd.edu.au>

2. American Society of Tropical Medicine and Hygiene – information on the ASTMH's programs, conferences, newsletters, publications, and resources.
<http://www.astmh.org >
3. The American Mosquito Control Association's site containing information on mosquito biology, AMCA programs, conferences, newsletters, publications, and resources.
<http://www.mosquito.org>

4. Reuters' search engine on health news pertaining to health issues around the world.
<http://www.reutershealth.com/>

5. The ORSTOM home page includes information about the organization's medical research program in Asia, Africa, and Latin America. Bulletins and publications on its research are offered.
<http://www.orstom.fr/>

6. Emory University's website allows access to the University's extensive database of medical and scientific literature, including infectious diseases.
<http://www.medweb.emory.edu/medweb/>

7. The Entomological Society of America offers information on its overall services, including conferences, journals, references, membership, and literature available for ordering.
<http://www.entsoc.org>

8. Travel Health Online contains country profiles with health precautions and disease risk summaries, general travel health advice, contacts for providers of pre-travel health services, and access to U.S. State Department publications.
<http://www.tripprep.com>

9. The CIWEC Clinic Travel Medicine Center is the best source of Western medical care in Nepal. The clinic was established in 1982 and has focused on the health problems of foreigners in Nepal. The clinic maintains a website that is updated regularly to provide the latest information regarding health risks in Nepal.
<http://ciwec-clinic.com>

10. The Institute of Tropical Medicine, Nagaski University, website. Contains information on medical entomology.
<http>://www. tm.nagasaki-u.ac.jp/medical>

14. Major Scott Stockwell, U.S. Army, has compiled this website on scorpion stings, phylogeny, classification and identification as well as links to other scorpion websites. <http://wrbu.si.edu/www/stockwell/classification/classification.html

Appendix I. Metric Conversion Table.

Metric System

LINEAR MEASURE

10 millimeters	=	1 centimeter
10 centimeters	=	1 decimeter
10 decimeters	=	1 meter
10 meters	=	1 decameter
10 decameters	=	1 hectometer
10 hectometers	=	1 kilometer

AREA MEASURE

100 sq. millimeters	=	1 sq. centimeter
10,000 sq. centimeters	=	1 sq. meter
1,000,000 sq. millimeters	=	1 sq. meter
100 sq. meters	=	1 sq. are
100 acres	=	1 hectare
100 hectares	=	1 sq. kilometer
1,000,000 sq. meters	=	1 sq. kilometer

VOLUME MEASURE

1 liter	=	0.001 cubic meters
10 milliliters	=	1 centiliter
10 centiliters	=	1 deciliter
10 decaliters	=	1 liter
10 liters	=	1 decaliter
10 decaliters	=	1 hectoliter
10 hectoliters	=	1 kiloliter

WEIGHT

10 milligrams	=	1 centigram
10 centigrams	=	1 decigram
10 decigrams	=	1 gram
10 grams	=	1 decagram
10 decagrams	=	1 hectogram
10 hectograms	=	1 kilogram
1,000 kilograms	=	1 metric ton

U.S. Customary System

LINEAR MEASURE

12 inches	=	1 foot
3 feet	=	1 yard
5 ½ yards	=	1 rod
40 rods	=	1 furlong
8 furlongs	=	1 mile
3 land miles	=	1 league

AREA MEASURE

144 sq. inches	=	1 sq. foot
9 sq. feet	=	1 sq. yard
30 ¼ sq. yards	=	1 sq. rod
160 sq. rods	=	1 acre
640 acres	=	1 sq. mile
1 sq. mile	=	1 section
36 sections	=	1 township

LIQUID MEASURE

4 gills (2 cups)	=	1 pint
2 pints	=	1 quart
4 quarts	=	1 gallon

DRY MEASURE

2 pints	=	1 pint
8 quarts	=	1 peck
4 pecks	=	1 bushel

WEIGHT

27 11/32 grains	=	1 dram
16 drams	=	1 ounce
16 ounces	=	1 pound
100 pounds	=	1 hundredweight
20 hundredweight	=	1 ton

Kitchen Measurements

3 tsp.	=	1 tbsp.	5 1/3 tbsp.	=	1/3 cup	2 cups	=	1 pint	2 pints	=	1 quart
4 tbsp.	=	¼ cup	16 tbsp.	=	1 cup	4 cups	=	1 quart	4 quarts	=	1 gallon

Temperature

Celsius = $\frac{5}{9}(F-32)$ Fahrenheit = $\frac{9C}{5} + 32$

Conversion Table

To Convert	Into	Multiply by	To Convert	Into	Multiply by	To Convert	Into	Multiply by
Centimeters	Inches	.394	Liters	Cups	4.226	Miles	Feet	5,280
	Feet	.0328		Pints	2.113		Yards	1,760
	Meters	.01		Gallons	.264		Kilometers	1.609
	Millimeters	10		Milliliters	1000	Pints	Liters	.473
				Quarts	1.057		Quarts	.5
Meters	Centimeters	100	Grams	Ounces	.035		Gallons	.125
	Feet	3.281		Pounds	.002	Quarts	Pints	2
	Inches	39.37		Kilograms	.001		Liters	.946
	Kilometers	.001	Kilogram	Grams	1,000		Gallons	.25
	Miles	.0006214		Ounces	35.274	Gallons	Pints	8
	Millimeters	1000		Pounds	2.205		Liters	3.785
	Yards	1.093	Inches	Centimeters	2.54		Quart	4
				Feet	.0833	Ounces	Grams	28.35
Kilometers	Feet	3281		Meters	.0264		Pounds	.0625
	Meters	1000		Yards	.0278		Kilograms	.028
	Miles	.621	Yards	Inches	36	Pounds	Grams	453.59
	Yards	1093		Feet	3		Ounces	16
				Meters	.914		Kilograms	.454
				Miles	.0005682			